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GEOLOGICAL SURVEY
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Met 'n opsomming in Afrikaans onder die opskrif:

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THE KAOLIN DEPOSITS OF THE AREA BETWEEN BITTERFONTEIN AND LANDPLAAS, VANRHYNSDORP DISTRICT

ABSTRACT

In the area to the south, west and southwest of Bitterfontein there is a complex of metamorphic rocks derived essentially during two stages of metamorphism from sedimentary rocks of the Malmesbury Formation, and overlain by younger strata of the Nama System and of Recent age. The felspar in the granitic, gneissose, granulitic and schistose varieties of the metamorphic rocks has in many localities been altered to kaolinite, and these deposits of kaolin were investigated by the combined efforts of the C.S.I.R., the Geological Survey and the Superwhite Kaolin Corporation. In all, 26 occurrences were investigated, and the larger deposits were prospected.

Of the prospected occurrences, Nos. 1, 2, 3, 4, 5, 8 and 21 are of economic interest. Occurrence No. 1 (Nieuwhoudts Naauwte) will probably yield 312,000 tons of clean, washed, white kaolin with a reflectivity of up to 86. The precise reserves in occurrence No. 2 (Erd Vark Gat) are not known but they are probably large; the washed material has a reflectivity of 77, and 66 per cent. of the material has a particle size of less than 10μ . In each of occurrences No. 3 and No. 8, both situated on De Toekomst, there are reserves of 250,000 tons of washed kaolin; the percentage of particles smaller than 5μ is respectively 81 and 88, and the reflectivity in occurrence No. 3 varies between 62.5 and 82.5 and in the other between 69 and 85. Occurrences Nos 4 and 5 are both situated on Moedgewin; occurrence No. 4 is the larger with a probable reserve of 46,500 tons of washed kaolin of which 77 per cent. has a particle size less than 5μ and a reflectivity as high as 86. Occurrence No. 21 (Hendriksvlei) has large reserves: 1,500,000 tons of raw material of good quality, and 9,000,000 tons of raw material of poor quality. The recovery of -325 mesh material is up to 62 per cent., and the reflectivity is as much as 85.

Occurrences No. 6, 7, 20, 22 and 25 may merit further prospecting, but the remainder are either too small or the quality too poor to be of economic interest.

In general, a recovery of kaolin of between 40 and 60 per cent. is obtained from the raw material, the main contaminant being quartz in fairly coarse particles. The washed material is of a quality that will make it of interest to the ceramic, paper, rubber and insecticide industries. The green strength is generally low, but the fired colour is good: some of the material of poorer quality may be improved by bleaching. Volume changes with

firing are generally not large.

Laboratory investigation indicates that the felspar altered directly to kaolinite and not through an intermediate stage of sericite. It is practically certain that this alteration was caused by superficial weathering agencies, probably during a more humid phase when chemical weathering was ascendant over mechanical weathering.

I. INTRODUCTION

A. GENERAL

When the area south and southwest of Bitterfontein was geologically mapped some years ago, notice was taken of the presence of kaolin (Jansen, 1960) and of the activities of various companies in developing some of the deposits. Interest in the kaolin received an impetus with the establishment of the Superwhite Kaolin Corporation; this corporation ultimately endowed a fellowship in the National Chemical Research Laboratory of the South African Council for Scientific and Industrial Research. At this stage an agreement was reached between the Superwhite Kaolin Corporation, the C.S.I.R. and the Geological Survey whereby the holder of the fellowship would investigate the areas held under option by the corporation and the Geological Survey would be in technical control of these investigations and would itself investigate the rest of the potentially kaolin-bearing area. The laboratory study of clay from the various deposits was undertaken in the laboratory of what came to be known as the Ceramics Unit of the C.S.I.R., although a small proportion of this work was done in the laboratory of the Geological Survey.

The field-work was completed during 1959 and the laboratory investigations during 1959 and 1960, and this bulletin presents the results of this combined investigation.

The area investigated for deposits of kaolin is situated in the northwestern part of the Cape Province in the District of Vanrhynsdorp. It is bounded by lines 31° latitude on the north, 31° 30' latitude on the south, 18° 30' longitude on the east and by the Atlantic Ocean on the west. Bitterfontein and Nuwerus are two small villages in the northeastern part of the area. For the actual localities of kaolin deposits the reader is referred to the accompanying map (folder 1).

B. COMMUNICATIONS

The area is fairly accessible with the exception of the sandy coastal belt. The main road from Vanrhynsdorp to Springbok passes through Bitterfontein and the north-eastern portion of the area. Provincial roads link Koekenaap with Nuwerus, and Koekenaap via Landplaas and Komkans with Biesjesfontein. There is a whole network of farm roads, but these are often in a poor condition. All the kaolin deposits are accessible either by road or track. The area is also traversed by the railway from Cape Town to Bitterfontein, a total distance of 289 miles.

C. PHYSIOGRAPHY

The area consists of a coastal plain bounded on the

east by hilly country. The coastal plain is flat to slightly undulating, and for the greater part covered by sand. In the northwestern part of the area the younger granite forms prominent hills. In the south-eastern and northern parts of the area there are several conspicuous hills composed of gneiss: in many cases they are capped by Nama quartzite. These hills range in height from 1,150 to 1,900 feet above sea-level. Quartz veins give rise to conspicuous, steep-sided ridges.

Depressions in hilly, gneiss country frequently follow fault-zones, such as between Nuwerus and Nieuwhoudts Naauwte. These depressions may also be parallel to the strike and foliation in the metamorphic rocks.

The area has an arid to semi-arid climate and the average annual rainfall is less than 250 mm. All rivers are intermittent. The river-courses frequently follow directions of joint-planes or pre-existing fault-zones, e.g. the Groot Goerap River between Vleifontein and Stuurman.

The vegetation is sparse and consists mainly of scattered succulents; in the higher regions the vegetation may be more dense.

D. WATER SUPPLY

Owing to the arid conditions in the area, springs and seepages with a perennial flow are not represented. The area is drained by water-courses that are dry throughout the greater part of the year. A few water-holes supplying brackish water are found in dry streambeds.

The averages of 21 successful bore-holes in pink gneiss are as follows:

Average total depth of boreholes in feet	153
Average depth at which water was struck, in feet	120
Average depth to which water rises, in feet .	65
Average yield, in gallons per hour	1,178

The relatively high yields are greatly influenced by bore-holes located near or on post-Nama faults, i.e., near the faulted contacts between gneiss and Nama quartzite, or near sheared zones in gneiss. The average yield of bore-holes not located in the vicinity of faults amounts to only 160 gallons per hour.

An analysis of the brackish water from one of the bore-holes is given below (Jansen, 1960).

	p.p.m.
Total dissolved solids	3400.0
Alkalies (as Sodium)	1020.0
Ca	115.0
Mg	7.0
Fe	0.17
Sulphate (as SO_4)	339.0
Carbonate (as CO_3)	101.0
Silica	35.0
Carbonate hardness (as $CaCO_3$) .	169.0
Non-carbonate hardness	478.0
Total hardness (as $CaCO_3$)	647.0

This water is not suitable for human consumption, since the maximum tolerable amount of total dissolved solids in water that may be taken over a long period

without harmful effects is of the order of 1,500 p.p.m.

For industrial purposes, e.g. washing of kaolin, it will also be useless due to contamination of the washed product by the dissolved solids.

II. GENERAL GEOLOGY

The subject matter of this chapter is mainly a summary of Jansen's work published in 1960. The authors, who could not make a thorough study of the geology of this area, are in agreement with Jansen's findings as far as field observations are concerned. (See folder 1 for a simplified geological map.)

A. HOST-ROCKS

By far the greater part of the area is occupied by a complex of gneissic and metamorphic rocks. These rocks are considered to have been derived from the sediments of the Malmesbury Formation by processes of metamorphism, metasomatism and eventually granitisation.

The Malmesbury Formation, comprising the oldest rocks in this area, is exposed in the southeastern portion of the area (see folder 1) on the farms Moedverloren, Mostertskop and Groot Graaf Water. The chief rock-types in this formation are quartzite, phyllite, limestone and marble. Owing to the fact that these rocks are practically devoid of felspar, one would not expect them to be kaolinised.

Occurring within the pink gneiss of the complex are streaks, xenoliths and skialiths of metaquartzite, schist,

amphibolite and paragneiss that represent the metamorphosed but non-granitised equivalents of Malmesbury sediment.

The pink gneiss and the granulite, which occupy the greater part of the area, are considered to represent granitised Malmesbury sediment. The pink gneiss and the granulite, as well as the other metamorphic equivalents of the Malmesbury Formation within the complex already mentioned, originated during what is termed the first cycle of metamorphism and metasomatism. During this cycle, the rocks that were so affected became mobilised. Evidence of this mobilisation can be seen on Drooge Kraal, where the gneiss has an intrusive relationship relative to the Malmesbury Formation. The gneiss and the granulite are essentially composed of felspar and quartz and are therefore particularly amenable to kaolinisation, where conditions are favourable. The majority of the kaolin deposits in the area were derived from the gneiss, e.g. on Nieuwhoudts Naauwte, Erd Vark Gat, Vleifontein, Stuurman and Elandsfontein.

The first cycle of metamorphism was followed by a second cycle also involving large-scale granitisation. During this cycle, large feldspar porphyroblasts grew in the gneissic and other metamorphic rocks. The rocks so formed are porphyroblastic granite, granodiorite, diorite and gneiss that cut across all pre-existing structures. These rocks occur extensively in the northern and northwestern part of the area. Kaolinisation of these rocks occurs on Hendriksvlei and Brandseklipheuwel.

Subsequent to the first and second cycles of metamorphism and metasomatism there followed a period of intrusive activity. Basic and lamprophyric rocks were emplaced before acid and intermediate types. This period was concluded by the emplacement of large granite plutons The rocks comprising this magmatic suite are mainly granite, syenite and lamprophyric and alkaline rocks, and they are mainly confined to the northwestern portion of the area. No known kaolin deposits are located in these rocks.

There followed a long period of erosion whereby the land surface became denuded. This was followed by gradual subsidence of the land beneath the sea during which time the Nama sediments were deposited on top of the old eroded surface. Subsequent uplift of the land resulted in the Nama sediments being exposed and in turn eroded. Quartzite and shale are the two chief rock-types of the Nama System. The quartzite in many cases forms flat-lying cappings to the hills in the eastern and north-eastern parts of the area. These flat surfaces of the hills probably represent an old erosion surface.

On the farm Brandseklipheuwel and De Toren there occur certain surface deposits in the form of thin, horizontal to slightly inclined beds overlying kaolinised granite and gneiss. They consist mainly of ferruginous pebbles cemented by secondary ferruginous and siliceous material. Similar ferruginised and silicified beds are found in various localities in Bushmanland and Namaqualand. Reuning (1931) who described some of these beds,

correlates them with the Pomona quartzite of South West Africa, which appears to be of late Cretaceous or early Tertiary age. The period of desiccation which brought about the silicification and ferruginisation of these deposits, probably started somewhat later than the Eocene, according to Gevers (1937).

Along the coast there are alternating beds of sand, sandstone, gravel, marl and clay with some lignite; they are probably also of Tertiary age. Quaternary deposits are represented by alluvium, aeolian sand, river-terrace gravel and raised beach deposits.

B. STRUCTURE

Folding occurred in the Malmesbury sediments and is reflected in the gneissic complex. The Malmesbury beds are thrown into major anticlines and synclines. Open folds and cross-folds predominate in the complex where syntaxis of fold axes occurred.

Post-Nama faulting occurred extensively in the northeastern and eastern portions of the area. The faults generally strike in a southeasterly direction. Branch-faults and parallel faults are common, and the fault-planes are in many cases filled by quartz veins. Kaolinisation of the country rock appears to have been controlled to a large extent by the presence of fault-zones, since many of the large kaolin deposits are located on or near faults.

III. KAOLIN OCCURRENCES

It may be convenient to divide the occurrences geographically into: 1) An eastern group comprising occurrences 1, 2, 3, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19; and 2) A western group comprising occurrences 4, 5, 6, 7, 20, 21, 22, 23, 24, 25, 26 (see folder 1).

A. EASTERN OCCURRENCES

1. Occurrence No. 1 (Nieuwhoudts Naauwte)

This deposit is situated approximately 8.5 miles southeast of Bitterfontein by farm road. For a detailed map of the occurrence see folder 2.

The kaolin occurs on the lower slopes of a hill where a number of shafts, trenches, adits and galleries have been driven into the hill. The hill is capped by quartzite of the Nama System and immediately underneath this capping further prospecting holes have again proved the presence of kaolinised granite-gneiss. On the western side of the valley, which cuts the deposit more or less in half, the weathered material appears to be very hard and yellow in colour (holes Nos. 17, 18, 19, 20, 21, 22). However, most of these holes are shallow and whiter material may be found at depth. In the valley, the overburden is extensive, as indicated by hole No. 16 with an overburden of 13 feet 6 inches. On the eastern side of the valley, good-quality kaolin was established, but elsewhere the quality is poor.

This kaolin deposit has been derived from a very coarse-grained granite-gneiss, probably in part biotitic, the texture of which has been retained. No sericite was seen, but everywhere it is noticeable that the deposit is criss-crossed with quartz veins and cracks.

The maximum known depth of the deposit as exposed in the workings, which do not reach bottom, is 80 feet. It would be worth while to determine the actual depth of the deposit. At the moment, the estimated quantity of washed kaolin available from this deposit is approximately 312,000 tons, based on a 40 per cent. recovery from white, sorted, raw material that will require no bleaching. If bleaching can be resorted to in the washing-plant, then the tonnage of recoverable kaolinitic material at this deposit may be as high as 1,000,000 tons.

From a representative 1-ton sample from the workings at Nieuwhoudts Naauwte, two large bulk-beneficiated kaolin samples were prepared. The sample NN-10 reported on below was obtained by fractionation from hand-sorted material out of the representative 1-ton sample. The sample marked NNb-10 was a fractionated but chemically bleached kaolin obtained from the representative 1 ton of raw material which was not hand-sorted. When the chemical and physical properties of this bleached and washed kaolin (NNb-10) are compared to those of the hand-sorted, unbleached and washed kaolin (NN-10), it is noted that the latter material essentially differs only in having a higher green strength. To bleach effectively the unsorted material and improve its

reflectivity from 79 to 83, it was necessary to use 1 per cent. of sodium hydrosulphite.

Kaolin Sample No.:	NN-10	NNb-10
Chemical Analysis	%	%
SiO_2	48.48	49.44
Al_2O_3	36.91	35.60
Fe_2O_3	0.49	0.62
TiO_2	trace	trace
CaO	0.35	0.06
MgO	1.18	0.80
K_2O	1.08	0.59
Na_2O	0.06	0.04
Loss on ignition	12.24	12.55
	100.59	99.70
Mineralogical Analysis	%	%
Kaolinite	87	90
Quartz	1	2
Hydrous Mica	12	8
Particle Size Distribution	%	%
+ 30μ	7	10
- 30μ	93	90
- 10μ	87	85
- 5μ	72	69
- 2μ	49	45
- 1μ	34	32
Reflectivity "Photovolt" reflectometer	86	83
Fired colour at 1,200°C	white	white
Fired shrinkage at 1,200°C	8%	8%

Kaolin Sample No.:	NN-10	NNb-10
Green strength at 80°C	210 lb/sq.in.	140 lb/sq.in.
Shrinkage at 80°C	3%	

The ceramic, paper, paint and rubber industries should find the above-mentioned types of washed kaolin satisfactory for their needs.

Kaolin was formerly produced from this deposit by Dr. J. Nortje and J. Gauche of Vredendal, but it is not known how much was produced and sold.

2. Occurrence No. 2 (Erd Vark Gat)

Kaolin was produced from this deposit for a number of years by the now defunct Brackenware Company. The quarry is situated 10 miles southeast of Bitterfontein near the village of Nuwerus, next to the main road leading to Vanrhynsdorp. It occupies the site of a post-Nama fault at the foot of a hill capped by quartzite of the Nama System.

The quarry itself has an established working face of about 200 feet over a maximum height of 25 feet. The pure white, kaolinised granite-gneiss is not uniform throughout but is considerably richer in very coarse quartz in the east than in the main face which is directed into the slope of the hill. The texture of the parent-rock has been retained to a large extent. No sericite was seen, but there are a number of quartz veins present in the kaolinised granite-gneiss.

A number of prospecting pits are present in an area extending for approximately 100 yards from the quarry and established the presence of kaolinised granite up the side of the hill for a considerable height above the height of the quarry floor, so that reserves are undoubtedly very large.

Plate I clearly shows the iron-rich cracks and areas which resulted in the necessity for hand-sorting of the mined material. Bleaching in the beneficiation process should eliminate selective mining.

From a sample collected at this quarry the following data on the -325 mesh material (65.5 per cent. recovery) were obtained:-

Chemical Analysis

SiO_2	53.75
Al_2O_3	28.31
Fe_2O_3	3.36
TiO_2	0.70
CaO	0.08
MgO	0.94
K_2O	3.33
Na_2O	0.17
Loss Ign.	9.98
	100.62

Particle Size Distribution

	%
+25µ	13
-25µ	87
-10µ	66
- 5µ	53
-2.5µ	36

Reflectivity

"Photovolt" reflectometer: 77

3. Occurrence No. 3 (De Toekomst)

This is located on the farm De Toekomst, portion of Erd Vark Gat, 13.5 miles southeast of Bitterfontein. For a detailed map of the deposit see folder 3.

Fairly extensive prospecting operations were carried out by the Superwhite Kaolin Corporation on this deposit. Prospecting was done by sinking pits at regularly spaced intervals. The average depth of the pits is about 5 feet, but pits 2, 7 and 24 were sunk to depths of 30 feet, 23 feet and 72 feet respectively. Hand-auger drilling was resorted to in certain places.

The proved areal distribution of the deposit is about 200 yards by 200 yards. It is situated near a large quartz vein that marks the position of a post-Nama fault - the same fault as that on which occurrence No. 2 is situated. The deposit has a gradual westward slope and is bordered on the west by a lime-rich formation and on the south by undecomposed augen-gneiss. The overburden varies from 1 to 5 feet in thickness and is usually very

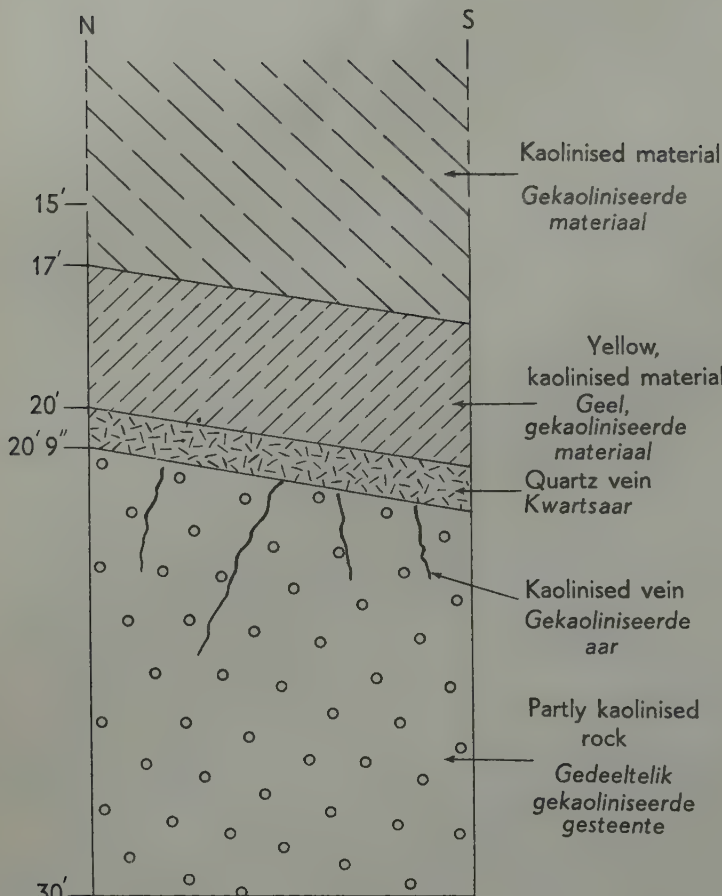

Fig. 1. - Section exposed in wall of pit No. 2, occurrence No. 3 (De Toekomst).

hard.

The kaolin has been produced at the expense of granite-gneiss and granulite. At a depth of 30 feet, pit No. 2 showed the section represented in fig. 1. The yellow material seems to have been derived from a type of schist, as it appears to be very fine-grained with no visible quartz grains. Below the quartz vein, the material is again white, but unaltered felspar can be easily recognised. In this case, the quartz vein may have acted as an impervious barrier. A similar transition of kaolinised rock to partly kaolinised material was noticed in pit No. 7 at 23 feet, but here the quartz vein was absent. In pit No. 24 unaltered granite-gneiss occurs at 54 feet and the degree of kaolinisation decreases progressively to that depth. This downward transition of kaolinised rock into unkaolinised material would support a theory of origin by alteration through surface agents.

At present a potential recovery of 250,000 tons of white kaolin may be expected from this occurrence.

In the following table, results of a laboratory investigation of samples collected as representative of this deposit are recorded.

Pit No.	Depth of Sample	%-325 Mesh Recovery	Reflectivity
1	2' - 4'	41	80
	6' - 8'	38	77.5
2	2' - 4'	40	73.0
	11' - 13'	42.5	69.0
	15' - 17'	37	73.5
	17' - 19'	59	70.5
	20' 9" - 30'	27.5	81.5
3	3' - 5'	32.5	77.0
	7' - 9'	35	78.0
4	2' - 4'	59.5	74.0
	6' - 8'	43.5	75.5
5	6' - 8'	45.5	77.0
6	3' - 5'	71	76.0
	7' - 9'	53.5	76.0
7	4' - 6'	54	72.5
	8' - 10'	51	76.5
8	2' - 4'	56	72.0
	6' - 8'	55.5	75.0
9	4' 6" - 5' 6"	62	75.0
10	3' 6"	55.5	78.0
11	4'	53	72.0
12*	5'	62.5	79
13	4'	64	73
14	5'	59.5	70
15	1'	59.5	74
16*	2' 6"	48.5	76
17	3'	65	68
18	3' 6"	63	69
19*	3'	50	76.5
20*	5' 6"	50	75
21	5'	62.5	62.5
22	6'	60.5	74
23	4' 6"	57.5	78.5
24	23'	57.5	77
25	7'	67.5	76
26	3' 6"	63	79.5
27	2' 6"	47	77.5
31	4'	56.5	68.5
32	3'	85.5	68

Pit No.	Depth of Sample	%-325 Mesh Recovery	Reflectivity
34	3' 6"	62	74.5
35	3' 6"	55	73.5
39	5'	78.5	82.5

In the vicinity of holes Nos. 1, 2 and 3, the recovery values are low, but for the rest of the deposit the average is above 50 per cent. This of course applies to the -325 mesh recovery, but actually the recovery of -10μ material (which produces a kaolin low in mica and quartz) for this deposit, as in the case of the Nieuwhoudts Naauwte deposit, amounts to about 40 per cent.

Generally, the reflectivity values are poor, i.e. less than 80. Upon bleaching a mixture of samples from holes Nos. 12, 16, 19 and 20 (marked * in the Table) which had a natural reflectivity of 78, an improved value of 80 was obtained. The kaolin in this deposit therefore does not appear to be of interest to the paper industry, but it fires to a very good white, and possibly would be useful in the ceramic, rubber or paint industries.

A -10μ fraction obtained from a mixture of the -325 mesh material from all the above holes amounted to a 37 per cent. recovery and gave the following chemical and particle size analyses that can be taken as representative of the deposit as a whole :

Chemical Analysis

SiO_2	47.54
Al_2O_3	36.00
Fe_2O_3	1.04
TiO_2	0.60
CaO	0.23
MgO	0.58
K_2O	0.48
Na_2O	0.40
Loss on ignition	12.70
	99.57

Particle Size Distribution

	%
+30μ	7
−30μ	93
−10μ	90
− 5μ	81
− 2μ	52
− 1μ	36

4. Occurrence No. 8 (De Toekomst)

Also situated on the farm De Toekomst, this deposit is located about 11.5 miles from Bitterfontein, a few hundred yards from the main road leading to Vanrhynsdorp. A plan of the deposit is represented on fig. 2.

The Superwhite Kaolin Corporation prospected this deposit in the same manner as occurrence No. 3.

It occurs in a zone of quartz veins, many of them

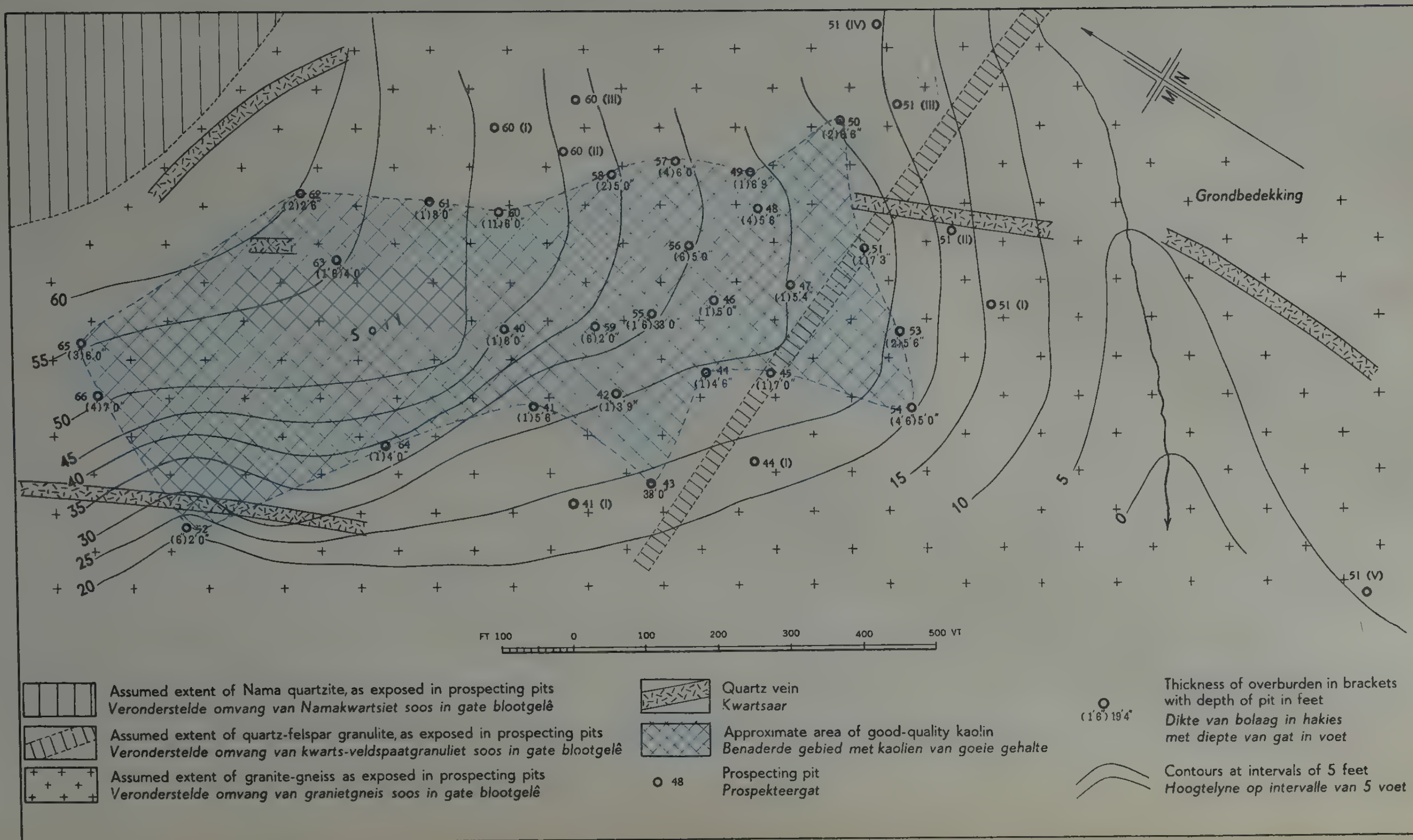

Fig. 2. - Plan of area prospected for kaolin on De Toekomst (deposit No. 8).

brecciated, which represents a fault that is most probably a continuation of the one that borders occurrence No. 2. The kaolinised rock consists of a coarse-grained gneiss alternating with a very sandy quartz-felspar granulite.

Gradual transition of kaolinised material into partly kaolinised material was observed in pit No. 43.

At the time of investigation, a potential kaolin recovery (white) of 250,000 tons was computed.

In the following table the results of laboratory tests on samples collected at this deposit are recorded.

Hole No.	Depth (Overburden in brackets)	% -325 mesh Recovery	Reflectivity
40	6'	51	70
41	5' 6"	55	81
42	3' 9"	59	77
43	7'	58.5	79.5
44	4' 6"	52.5	78.5
45	7'	42	85
46	5'	54	77.5
47	5' 4"	51.5	83
48	5' 6"	57.5	80.5
49	6' 9"	48	80
50	6' 6"	46.5	78
51	7' 3"	46	84
52	2' (0' 6")	49	71.7
53	2' (5' 6")	50	75.1
54	5' (4' 6")	43	71.2
55	4' (1' 6")	50	71.2
56	5' (6")	50	73.0
57	6' (4')	58	74.1

Hole No.	Depth (Overburden in brackets)	% -325 mesh Recovery	Reflectivity
58	5' (2')	45	74.0
59	2' (6")	55	72.7
61	5' (1')	40	79.2
62	2' 6" (2')	32	76.4
63	4' (1' 6")	54	74.0
64	4' (1')	48	75.0
65	6' (3')	43	75.9
66	6' (4')	55	77.7
66	7' (4')	44	69.0

Here again an average 40 per cent. recovery of good-quality kaolin was obtained from a composite of the 27 samples. The -10μ fraction gave a reflectivity of 81 and it is obvious that this deposit is much more promising than occurrence No. 3 (De Toekomst) as a potential supply of paper kaolin. The chemical and particle size analyses representative of the kaolin from this deposit are :

Chemical Analysis

	%
SiO_2	49.55
Al_2O_3	35.21
Fe_2O_3	0.83
TiO_2	0.59
CaO	trace
MgO	0.84
K_2O	0.73
Na_2O	0.09
Loss on ignition	12.62
	100.46

Particle Size Distribution

	%
+ 30μ	5
- 30μ	95
- 10μ	93
- 5μ	88
- 2μ	61
- 1μ	41

The white fired colour of this representative sample and a green strength value of 180 lb/sq.in. should also make this deposit of interest to the ceramic industry.

5. Occurrences Nos. 18 and 19 (Kersbosvlei)

These occurrences are to be found on the farm Kersbosvlei, part of Elandsfontein, next to the Koekenaap-Nuwerus road, 10 miles from Landplaas Siding. The owners had a few prospecting pits made, mainly to collect samples for certain interested parties. Not much information could be gathered from these pits, since they are few in number and lack depth, the deepest being about 3 feet.

The kaolin occurs intermittently over a distance of approximately 1.5 miles on either side of the road. The occurrences seem to be in the form of small, isolated patches of kaolinised country rock. The rocks kaolinised are gneiss, granulite and thin pegmatitic veins cutting through them.

The quality of the kaolin is generally poor, being in most cases coloured red, yellow or pink, and containing abundant quartz. In some cases, kaolinisation of

the felspar has not been complete. Fairly good-quality kaolin, white in colour and with little quartz, was observed in only two pits, and may be derived from the pegmatitic veins.

Patches of quartz float indicate the presence of hidden quartz veins. There is no evidence that any faulting took place in this area.

Samples from this area gave the following results on laboratory examination :

% Recovery : -325 mesh	Reflectivity
50	72
63	-

The available evidence does not indicate the presence of any appreciable reserves. Further prospecting operations may, however, reveal the presence of hitherto hidden deposits that may be of economic interest.

6. Minor Occurrences

For the location of these occurrences see folder 1. They all seem to be of small extent and the quality of the kaolin is usually inferior.

No. 9 - The kaolinitic material seems to be derived from a metaquartzite, which would result in a poor recovery. The colour of most of the material is yellow to brownish. No faults seem to be associated with this deposit and it appears of little promise.

No. 10 - Here the kaolin occurs in an old well now completely caved in. No outcrops occur in the vicinity, and it will be necessary to do horizontal and vertical prospecting to determine the quality and quantity of this deposit. Again, no faults seem to be associated with this deposit.

No. 11 - The occurrence on Driekuil is similar to the adjacent occurrence No. 1 on Nieuwhoudts Naauwte in lying between two faults. It does not appear to have the areal distribution of the Nieuwhoudts Naauwte deposit, and at present no additional information is available.

No. 12 - This is located on Erd Vark Gat below Rooiberg next to a major fault. There are several outcrops of kaolinised gneiss but there do not seem to be any substantial reserves.

No. 13 - Similar to No. 17.

No. 14 - Only slightly kaolinised material is present which lacks the quality to be of any economic importance.

No. 15 - A few prospecting pits were sunk, but only one showed kaolinisation. At a depth of 4 feet some fresh felspar was encountered. It therefore seems to lack the depth, as well as surface area, to be of any economic importance.

No. 16 - Of the six prospecting pits sunk, only one contained white material, the rest being in yellow or pinkish material. This occurrence is therefore not at all promising.

No. 17 - Six prospecting pits were sunk, of which

three contained yellow material and three greenish-white material.

B. WESTERN OCCURRENCES

1. Occurrences Nos. 4 and 5 (Moedgewin)

Both these occurrences are located on the farm Moedgewin. Occurrence No. 4 is approximately 6 miles from Landplaas Siding, and No. 5 approximately 5.5 miles. Both deposits were prospected by the Superwhite Kaolin Corporation.

a. Occurrence No. 4

For a plan of the prospected area refer to folder 4.

The kaolin occupies the site of a fractured or faulted zone marked by the presence of numerous thin quartz veins. The fault trends in a northwesterly direction and could be traced as far as the farm Vleifontein, where occurrences Nos. 6 and 7 probably lie on the same fault.

The deposit consequently exhibits an elongated distribution along this fault and occurs over a length of about 2,000 feet. It was difficult to estimate the thickness of the deposit, since kaolinisation was confined to such a narrow belt along which there was no appreciable incision. Only one of the prospecting pits penetrated the kaolin mantle, namely pit No. 2, which was 11 feet deep. Here there was a gradual change from completely kaolinised material into partially kaolinised material, in which fresh felspar crystals could still be recognised. In one

instance drilling was carried to a depth of 60 feet without bottoming the deposit.

The deposit is covered by an overburden consisting of soil mixed with quartz gravel and/or calcrete and varying in thickness from a few inches up to 3 feet.

The quality of the kaolin varies considerably within short distances. Good-quality kaolin is found in only two places which lie on the primary zone of quartz veins. As one proceeds away from the quartz veins, the quality of the kaolin deteriorates rapidly. Prospecting revealed better-quality kaolin extending towards the northeast along a narrow belt that seems to be the locus of a secondary fracture-zone branching off from the main zone; the concentration of quartz float along this secondary belt supports this view. Even along the trend of the main zone, the quality of the kaolin varies to a great extent.

The good-quality kaolin is pure white, whereas the colour of the poorer types ranges from cream through shades of pink and red-brown to dark purplish-red. The colour may change abruptly from white to red, as was noticed in one instance. In many cases the kaolin is coloured near the surface only to become white again lower down.

All types of kaolin contain some quartz to a greater or lesser extent. In the two localities where good-quality kaolin is found, the quartz is predominantly in the form of veins varying in thickness from about 1 mm. to about 1 foot. The quartz in the poorer types is in the form of individual crystals, but veins may also occur. There are distinctly two ages of quartz: the quartz veins that

outcrop on the surface were brecciated and subsequently recemented by a younger intrusion of quartz. The quartz veins found in the body of the kaolin appear to be of the younger type, and this quartz has a characteristic, translucent, bluish-grey to smoky colour.

The kaolin often occurs as veins and pockets of pure white kaolin. These veins frequently traverse only partially kaolinised country rock, and most probably represent fracture fillings because they show sharp contacts. The larger pockets are more difficult to account for since it is difficult to visualise them as cavity fillings. Such pockets were only observed along the main zone of quartz veins.

Three different rock-types could be distinguished, namely, gneiss, quartz-felspar granulite, and schist. Outcrops are scarce and the contacts shown on the map are highly speculative, but the distribution of the different types could be inferred from information gathered from the prospecting pits. In most pits the rock is either kaolinised or weathered, so that the original rock-type could only be guessed from the relict texture and fabric. All three types have been kaolinised. The gneiss gave rise to a better-quality kaolin than the schist and the granulite; the products of the latter two rock-types contain abundant sericite and quartz respectively, and the product derived from the schist is also more intensely coloured. In those two localities where pockets of relatively quartz-free kaolin occur, the parent-rock seems to have been a pegmatite, composed

mainly of felspar.

The two chief controls which favoured and enhanced kaolinisation in this area seem to be that of structure and mineralogy, both contributing to an equal extent. The estimated quantity of washed kaolin (white) recoverable from deposit No. 4 is about 46,500 tons (44,000 tons at pit No. 1 based on an average depth of 60 feet and 2,500 tons at pit No. 4a based on an average depth of 12 feet).

Samples collected from prospecting holes at this deposit were examined in the laboratory to determine the percentage of minus 325 mesh material, and to obtain the reflectivity values of the washed material. A large ± 1-ton sample from hole No. 4a (folder 4) was also beneficiated at the laboratory to determine the physical and chemical properties of the kaolin and to have samples available for testing by interested parties locally or overseas.

The percentage recovery and reflectivity results obtained from the above mentioned samples were as follows:

Hole No.	Depth	% -325 mesh material	Reflectivity or colour
1	4'6" - 5'6"	77	74.5
	8'6" - 10'6"	77	77.5
	15'6" - 17'6"	60	77.0
	22'6" - 24'6"	68	74.5
2	5' - 6'	34	74
	10' - 12'	31	68
3	4' - 5'	32	pinkish
	8' - 9'	20	pinkish
4b	5' - 7'	22	pinkish
	10' - 11'	35	pinkish
4a*	12'	77	86
5	5' - 7'	23	yellowish
	10' - 12'	32	yellowish
13	16'	58	67.0
14	11'6"	41	66.5

* 1-ton sample

Only the material from holes Nos. 1 and 4a appeared white and this fact, plus the very poor recovery figures reported for holes Nos. 2, 3, 4b, 5, 13 and 14, substantiated the observation made in the field that the good-quality kaolin at occurrence No. 4 is limited to a narrow zone. In fact, the two spots of good-quality kaolin occur on two small hills (folder 4) and are surrounded by material that becomes progressively poorer in quality (recovery and colour) as it is followed outwards.

The 1-ton sample from hole No. 4a was crushed, blunged, screened, fractionated at 10 microns, filter-pressed, dried and finally crushed. Some chemical and physical properties of this material are:

Chemical Analysis

	%
SiO_2	48.06
Al_2O_3	37.16
Fe_2O_3	0.74
TiO_2	0.05
CaO	0.29
MgO	0.51
K_2O	0.03
Na_2O	0.19
Loss on ignition	13.65
	100.68

Mineralogical Analysis

99% Kaolinite

1% Quartz

Particle Size Distribution

	%
+30µ	9
-30µ	91
-10µ	88
- 5µ	77
- 2 µ	56
- 1µ	43
- ½µ	20

Reflectivity

86 ("Photovolt" reflectometer with blue filter)

Fired Colour and Shrinkage at 1,200°C

White and 5 per cent. respectively.

Green Strength and Shrinkage at 80°C

Very poor, could not be determined.

Drying shrinkage of 5 per cent. (28 per cent. H_2O).

This washed kaolin received very favourable comments from local and overseas paper industries (its high reflectivity value), and local wall-tile (low firing shrinkage and good colour), insecticide (high adsorption) and paint producers also showed interest in this material.

b. Occurrence No. 5

This occurrence is located approximately 2 miles west of deposit No. 4. Only a few prospecting pits were sunk. The size of the deposit is not known, but it appears to be smaller than the No. 4 deposit. The kaolin is the decomposition product of a gneiss with the original texture still preserved. In some of the pits the kaolin was coloured pink and red near the surface, but became white lower down. Further prospecting is required in order to ascertain the size of the deposit.

The samples collected from 4 holes at this locality gave the following results:

Hole No.	Depth	% -325 mesh material	Reflectivity
6	5' 6"	26	79.0
7	6' 6"	42	77.0
8	11'	86	71.0
9	6'	53	75.5

The preliminary sampling and testing of this deposit No. 5 shown that the material is similar to that occurring in hole No. 1 of deposit No. 4 reported above. Although the reflectivity values are too low to interest the paper producers, the material will be of use to the ceramic industry.

2. Occurrence No. 20 (Klipkraal)

This occurrence is situated next to the Koekenaap - Landplaas road approximately 4 miles from Landplaas Siding.

The kaolin occurs in a relatively low-lying area. The two larger occurrences are situated on the banks of two dry water-courses, and smaller, rather insignificant occurrences were also noticed in this area and all the occurrences have a more or less linear distribution.

The largest occurrence is exposed in the river bank and has a visible thickness of 12 feet and is exposed over a length of 200 feet. Its lateral extent is not known, since it is covered by sand and soil to a depth of several feet.

Only a small proportion of the kaolin is white, the rest being intensely coloured. Even the white kaolin is coloured along joint-planes. The whiter variety contains little quartz, and is soft so that it can be cut with a pen-knife. It may contain a good deal of finely-divided sericite. The pink, red and brown varieties contain much more quartz. All types contain a good deal of salt in the form of NaCl which can be tasted when a piece is laid on the tongue.

Outcrops of pink biotite gneiss are to be found in the vicinity, and this appears to be the parent-rock of the coloured varieties of kaolin. The better type of kaolin was probably derived from a pegmatitic rock containing mainly felspar.

Prospecting operations will have to be carried out in order to prove the extent of the deposit and to ascertain whether there is any improvement in the quality of the deposit in depth.

The smaller occurrence is located approximately 900 feet to the southeast of the larger one on the left bank of a tributary. Kaolin is exposed in patches over a length of 100 feet. The thickness is from 10 to 15 feet. The kaolin is generally white in colour, is hard and contains abundant quartz. A sample collected in this area had a -325 mesh recovery of 80 per cent.

3. Occurrence No. 21 (Hendriksvlei)

This deposit is located approximately 10 miles west of Komkans Siding.

The kaolin rights on the farm were held in 1959 by Dr. Nortje, of Vredendal, who had the area fairly extensively prospected. Prospecting was carried out by the digging of random pits, the depths of which range from 1 foot or less up to 100 feet.

The deposit is located in and on the flanks of a small valley trending roughly southeast. Outcrops of fresh rock are practically absent. The kaolin occurs as the residual, primary decomposition product of granite-

gneiss and schist. The schistose material occurs as streaks and bands within the granite-gneiss and ranges in thickness from a few inches up to several feet. There are two fairly extensive outcrops of surface quartzite overlying the kaolinised material.

The kaolin deposit covers a comparatively large area measuring approximately 7,000 feet by 2,200 feet (see folder 5). The thickness of the kaolinised mantle seems to increase as the elevation of the land increases, especially towards the house. It was noticed that some of the pits penetrated the kaolinised mantle into partially kaolinised material and in one instance into comparatively fresh rock. The deepest pit in the vicinity of the house (pit No. 2) was 40 feet deep; at this depth the kaolinised mantle had not yet been penetrated. Pit No. 4, which is located deeper down in the valley, was sunk to a depth of 100 feet, and here the kaolinised mantle was penetrated, although it was impossible to ascertain the depth at which the transition took place, since the pit had been covered. Judging, however, by the relative amounts of the material that were removed from the pit, it is possible to make a rough estimate of the depth at which transition took place; in this case it appears to be in the vicinity of 20 to 30 feet.

The thickness of the overburden, which consists mainly of soil and sand, varies considerably. In the vicinity of the house, it ranges from a few inches to 2 feet. As one goes towards the valley, the thickness increases slightly and attains a maximum of about 6 feet.

In pits Nos. 5, 6 and 7 the thickness of the overburden ranged from about 10 to 20 feet.

The kaolin is generally white, but in insolated spots it may be coloured pink, yellow or reddish-brown. The coloration is usually more intense near the surface. Impurities are quartz and mica. The original texture of the rock has been retained to a large extent. The Kaolinised products of the schistose material are generally poor and contain proportionally more mica.

Samples of good-quality kaolin from Hendriksvlei gave the following results on being tested in the laboratory; these figures certainly suggest that kaolin from this deposit could command a ready market.

% Recovery: -325 mesh	Reflectivity
62	81
58	85
59	83

There is an estimated reserve of 1,500,000 tons of crude, good-quality kaolin, and about 7,700,000 tons of crude, medium-quality kaolin. The reserves of poor-quality kaolin amount to about 9,000,000 tons giving a total of 18,200,000 tons of crude kaolin.

4. Other Occurrences in the West

There are a number of smaller occurrences in the west that do not seem to be of economic importance but are nevertheless described below. For their locations

see folder 1.

a. Occurrences Nos. 6 and 7

These occur on the farm Vleifontein and appear to lie on the same fracture-zone as the Moedgewin deposit (occurrence No. 4). The two deposits are located on the banks of a dry stream-bed. Some prospecting was done here by the Superwhite Kaolin Corporation.

The kaolin and parent material showed marked variations over short distances with the white material apparently occurring in bands.

It is recommended that prospecting operations be continued at these two deposits, since the quality appears to be satisfactory.

Preliminary investigation on samples from a few prospecting holes (data given below) indicated that a washed kaolin from these deposits would be similar to the very good-quality material from hole No. 4a of the Moedgewin occurrence No. 4.

Occurrence No. 6

Hole No.	Depth	% -325 mesh material	Reflectivity
1	12' 6"	55	80
2	8' 6"	61	78
3	6'-8'	88	84
4	4' 6"	66	82

Occurrence No. 7

Hole No.	Depth	% -325 mesh material	Reflectivity
5	2' 6"	69	84
6	8' 6"	62	78
7	8' 6"	44	77

b. Occurrence No. 22

This is located on the farm Stuurman, 1.5 miles from Waterklip Siding.

The kaolin is exposed in only one shallow pit from which samples were taken by interested parties. The kaolin is white, contains a fair amount of quartz and is probably the decomposition product of a granite-gneiss. There is no evidence to suggest that it lies on the same fracture-zone as those of Moedgewin and Vleifontein.

This occurrence is worth further investigation, since it is near the railway and the quality also appears to be satisfactory. A sample collected at this occurrence had a -325 mesh recovery of 45 per cent. and the fine material gave a reflectivity value of 79.

c. Occurrence No. 23

Old water-wells in the river bed on the farm Houtkraal revealed the presence of kaolin under an overburden from 5 to 10 feet thick. The kaolin is white and resembles that of Hendriksvlei (deposit No. 21), but contains more mica. A sample collected at a depth of between 9 and 11 feet had a 46 per cent. recovery of

-325 mesh material with a reflectivity value of 75.

d. Occurrence No. 24

This occurrence is to be found on the farm Adoonsevlei about 18 miles from Komkans Siding. The kaolin occurs at the foot of a low hill and is exposed in erosion gullies. Biotite gneiss and schist are the rocks kaolinised. The kaolinised schist cannot be considered as a possible source of kaolin, since it is always intensely coloured and consists predominantly of mica with only a little kaolinised felspar occurring interstitially. The schistose material grades into the kaolinised gneiss, the material at the same time becoming whiter in colour. The kaolinised gneiss, however, still contains abundant mica, and a good deal of quartz. There are numerous thin quartz veins cutting through the kaolinised country-rock.

A sample collected at this occurrence yielded a cream-coloured -325 mesh material (92 per cent. recovery).

The deposit seems to lack the quantity of good-quality kaolin to render it of any economic importance.

e. Occurrence No. 25

This deposit is about 2.5 miles west of deposit No. 24, on Katdoringvlei.

The kaolin was exposed in a small, roughly circular dam of 25 feet radius. The proved depth of the deposit is about 13 feet. It is covered by an overburden of about 1 to 3 feet in thickness.

Two types of kaolin were observed, namely, a soft, white variety containing little quartz but apparently a good deal of finely divided sericite, underlain by a coarse, white, harder type containing a good deal of quartz and mica. The colour is predominantly white. The two types were probably derived from different rock-types, the coarser one from a gneiss. There are no outcrops of fresh rock in the vicinity. The coarse type gave a recovery of 48 per cent. on -325 mesh, and the finer type 86 per cent.

It may be advisable to have this occurrence prospected in order to prove its extent.

f. Occurrence No. 26

This occurrence is to be found on the farm Brandseklipheuwel (part of Kogel Fontein). The kaolinised gneiss is partly overlain by a ferruginous surface deposit mentioned earlier. The resultant topography is that of low, flat-topped hills.

The quality of the kaolin is generally very poor, being intensely coloured, very hard, and containing abundant quartz. Two narrow (4 to 6 feet) bands of a softer, relatively quartz-free kaolin cut through the poor material. This kaolin is also much less coloured. The rocks that gave rise to these bands were probably pegmatitic in nature. A sample that was sieved through a -325 mesh amounted to a 76 per cent. recovery, but was pink in colour.

This deposit cannot be considered as of any economic

importance.

IV. QUARTZ AS A BY-PRODUCT

The main contaminant separated from the raw material by washing is quartz, which may be of interest as a soft abrasive or scouring material. From 40 to 60 per cent., but usually a proportion nearer the smaller figure, of the raw material is quartz, and the following table gives some idea of the size distribution of the particles in this possible by-product:

Sample Description	Occurrence No. 3 (De Toekomst : Hole No. 2					Occurrence No.23 (Houtkraal)	Occurrence No. 4 (Moedgewin)
	2-4'	11-13'	15-17'	17-19'	21-30'		
Screen Analysis of Material:							
% + 9 mesh	4	1	4	1	15	1	12
-9 +20 "	25	22	26	1	27	5	18
-20 +40 "	32	38	32	3	21	22	22
-40 +60 "	10	15	12	47	11	23	15
-60 +80 "	3	5	5	10	5	6	5
-80 +100 "	4	5	5	14	5	8	6
-100 "	22	14	16	24	16	35	22

V. ORIGIN OF THE KAOLIN

A. THEORIES

It has long been recognised that the mineral kaolinite is formed as a result of the decomposition of felspar. Other aluminous minerals, e.g. sericite, may also yield kaolinite upon decomposition. With the felspars the nett result of the process of kaolinisation is that all the potash, soda and lime, together with some of the silica, are removed, while some water is gained.

The alumina content remains constant. This process takes place in solution. The question now is: What is the nature of the solutions that cause kaolinisation?

Many theories have been put forward for the mode of formation of kaolin deposits, but it would be impossible within the scope of this work to go into any details of these.

Howe (1914) gave an excellent summary of the different theories. The origin of the Bitterfontein - Landplaas deposits will be examined in the light of the different theories as set out by him. The principal agencies of kaolinisation with which he deals are:

1. Surface weathering
2. Waters descending from swamps and bogs
3. Ascending spring waters containing CO_2
4. Emanations following igneous activity
5. Sulphuric acid solutions and hydrogen sulphide.

Before discussing the theories, it must be said that all the kaolin deposits investigated are the primary, residual, decomposition products of felspathic rocks like granite and gneiss and to a lesser extent granulite and schist. This fact is clearly demonstrated by the following phenomena: (i) the gradation of the kaolin into partially kaolinised rock and eventually into comparatively fresh rock; (ii) the relict texture shown by the kaolin; (iii) the tendency for kaolin deposits to occur on or near faults where the country rocks were rendered permeable for the passage of solutions and solvents.

1. Surface Weathering

It is an indisputable fact that certain rock-forming minerals, such as felspar, decompose into clay minerals when acted upon by ordinary processes of weathering. Thus are formed the clay mineral components of soils with kaolinite as one of the common components.

Factors such as parent-rock composition, climate, topography, vegetation and time have a profound influence on processes of weathering and hence on the type of decay product formed during weathering.

A cold, wet climate favours the formation of organic acids which cause iron and alumina to be leached out effectively. A hot, wet climate is one in which alkaline conditions prevail and hence one in which iron and alumina tend to be concentrated near the surface. Topography and the magnitude of the rainfall will determine the rapidity with which a given constituent is removed from the zone of weathering after the breakdown of the present mineral.

Grim (1953) states that the presence of alkalis and alkaline earths, particularly potassium and magnesium, in the environment of alteration and the length of time they remain in the environment after their liberation from the parent minerals, are important conditions in determining the kind of clay mineral formed. The presence of potassium leads to the formation of illite (sericite), while magnesium leads to the formation of montmorillonite. Calcium probably leads to the formation of montmorillonite and is antagonistic towards the

formation of kaolinite.

The origin of the pure white, often commercial, deposits of kaolin has also been attributed to normal processes of chemical weathering acting on felspathic rocks. Howe (1914) does not favour the idea that normal surface weathering can produce the high-grade, white clays. He reasons that the agency of surface weathering does not normally produce white kaolin clays, but a product quite different from it. Howe suggests that there are some special conditions during kaolinisation which allow the removal of the iron content, conditions which are absent in the ordinary process of weathering.

The difference in character between the ordinary weathering products of acid felspathic rocks and the white kaolin deposits of presumably the same parentage, is probably due to the fact that in the latter case they were formed predominantly by chemical weathering, while in the former instance mechanical weathering kept pace with and probably overshadowed the effects of chemical weathering.

It is certainly true, as Howe says, that it is erroneous to conclude that only certain granites, or acid felspathic rocks for that matter, are susceptible to kaolinisation by superficial agencies of weathering. That only <u>certain</u> acid feldspathic rocks are susceptible to superficial kaolinisation <u>under a given set of conditions</u> would perhaps be a more accurate statement.

The kaolin deposits in the Bitterfontein - Landplaas area appear to have been formed by ordinary superficial

agencies of weathering. In all the cases that were investigated to a sufficient depth, the bodies of kaolinised rock proved to be "bottomed" and to pass by gradation into unkaolinised rock. While it is probable that kaolinisation of the felspathic country rocks was promoted by such features as quartz veins and faults, the general level at which kaolinisation began can usually be related to erosion surfaces visible in the topography, e.g. on Brandseklipheuwel and Hendriksvlei.

The rocks which gave rise to the pure white kaolin contained very few or no iron-bearing minerals. Rocks that did contain iron-bearing minerals gave rise to coloured products. To say that conditions were such that iron was leached out from the white deposits is probably not true, because it was observed in one instance on Moedgewin that there was an abrupt change from pure white kaolin to intensely red-coloured kaolin. This can only indicate that there were two types of rock that were kaolinised - the one iron-bearing and the other not. It was also noted on Hendriksvlei that in the downward transition from kaolinised to comparatively fresh rock there was no increase in the amount of iron-staining, but that the material remained white. This also indicates that there were practically no iron-bearing minerals to start off with.

2. Waters Descending from Swamps and Bogs

In Germany kaolinised igneous rock is frequently overlain by brown-coal beds of Tertiary age. This led

German writers to believe that the kaolin was formed by the downward leaching of granitic rocks by waters descending from swamps and bogs. Such waters are charged with organic matter, humic and carbonic acids, and are deficient in oxygen. These waters are capable of kaolinising the felspar and at the same time reducing the iron to the soluble ferrous state.

This theory may account for the origin of certain German kaolin deposits, but there is no evidence to suggest that swamp and bog conditions prevailed in the area under discussion. Scattered lignite beds are found only along the coast. Farther inland there are no coal formations nor is there any evidence of their former existence.

3. Ascending Spring Waters Containing CO_2

It has been recognised for a long time that argillaceous alteration products are found associated with hot springs and geysers. Howe (1914) mentions that Stremme described as an example of such alteration the kaolinisation of granite at the Giesshüber spring near Carlsbad.

It is practically certain that such springs had nothing to do with the Bitterfontein - Landplaas deposits, since there is no evidence in the form of travertine, siliceous sinter or calcareous sinter to suggest that such springs did exist.

4. Emanations Following Igneous Activity

It is a well-established fact that clay minerals are

formed by hydrothermal action. The majority of clay occurrences of which the origin is attributed to hydrothermal action are usually of small magnitude and occur as alteration haloes surrounding metalliferous deposits. Sales and Meyers (1948) and Schwartz (1947) are some of the workers who investigated this type of clay occurrence. Their studies revealed that there is a zonal arrangement of the clay minerals. These zones are regarded by Sales and Meyers as reaction rims, while Schwartz regards them as having been formed by different solutions appearing at different times.

The kaolin deposits of southwest England are regarded by Howe (1914) as of hydrothermal origin. This theory is supported by features such as the great depth of alteration (over 350 feet), the occurrence within the kaolin of secondary minerals like tourmaline, topaz, fluorite and siderite, and the frequent association of kaolinite with fissure systems containing tin deposits. The hydrothermal origin of the Cornish kaolin is now well established by the finding of kaolin masses which are overlain by sills and which do not reach the surface (Grim, 1953.)

It is doubtful whether hydrothermal action had anything to do with the kaolin deposits of Bitterfontein - Landplaas. Associated hydrothermal metalliferous deposits are absent and zonation of clay minerals was not observed. Post-igneous emanations following the emplacement of granite in this area could not have been responsible for the kaolinisation, because the kaolin deposits are much too young (definitely post-Nama).

5. Sulphuric Acid Solutions and Hydrogen Sulphide

Lindgren (1915) and others are of the opinion that kaolin associated with metalliferous deposits was formed by the action of descending sulphuric acid solutions on felspathic and sericitic rocks. The sulphuric acid was formed by the oxidation of pyrite.

Howe (1914) is doubtful as to whether descending sulphuric acid solutions were responsible for kaolinisation. He holds the view that kaolinisation could have been established by ascending sulphuric acid solutions or possibly by hydrogen sulphide.

It is rather unlikely that sulphuric acid solutions were responsible for the kaolinisation in the Bitterfontein-Landplaas area, because of the absence of metalliferous sulphide ores which could have generated sulphuric acid. The presence of numerous gypsum deposits in this area may seem to indicate that sulphuric acid was active in this area. It is thought, however, that the gypsum deposits originated as a result of an entirely different set of circumstances and not as a result of the action of sulphuric acid on limestone.

B. GENESIS OF THE KAOLINITE - SOME LABORATORY INVESTIGATIONS

Samples of kaolin for laboratory investigation were taken from the larger deposits at Moedgewin, De Toekomst and Hendriksvlei. These samples include well-kaolinised

material from near the surface, partially kaolinised material taken deeper down, and fresh rock samples from the nearest outcrops.

Microscopic examination of thin sections of the fresh rocks showed that they are granite-gneisses composed essentially of quartz and felspar. Biotite is an accessory mineral in all of them. Iron ore, zircon and apatite were also noted in some of them. The gneiss from Hendriksvlei contains some muscovite, while hornblende was found in the gneiss from Moedgewin. Microcline, in most cases perthitic, is the dominant felspar in the gneiss from De Toekomst and Moedgewin, while orthoclase predominates in the gneiss of Hendriksvlei. The felspars show different degrees of alteration. In some cases they are merely cloudy and the nature of the alteration product could not be discerned. In other cases there is alteration to sericite along cracks and cleavage traces. The perthitic varieties show selective alteration, the plagioclase being the first to alter.

Thin sections of the partially kaolinised material were also microscopically examined. Here the felspars show much more alteration. In certain instances there is alteration to sericite, while in other instances the alteration product is in the form of masses of fine crystals of low birefringence and often showing accordion-like outlines. Although the latter product could not be identified, it is most probably kaolinite. Chlorite, which is most probably the alteration product of biotite, was also noted.

The quartz did not reveal any signs of change due to, for instance, leaching.

X-ray diffraction studies on the partially kaolinised felspars revealed the presence of felspar and kaolinite only. No sericite seems to be present. The fine fractions of the samples of Moedgewin and De Toekomst also contained no sericite, while that of Hendriksvlei contained only a little sericite. A sample from Nieuwhoudts Naauwte contained 12 per cent. hydromica.

Sand (1956) who carried out some extensive work on clays of the U.S.A., is of the opinion that secondary mica is an essential intermediate product in the formation of residual kaolinite from felspar. Grim (1953) states that sericite, or the mica-like alteration product which he calls illite, is only formed when leaching of potash from the host-rocks is rather slow. When potash is leached out rapidly, kaolinite is formed directly from the felspar.

The present investigation did not succeed in clearing up this problem. The microscopic examination showed that the felspars do alter to secondary mica in certain cases, but whether this secondary mica in turn alters to kaolinite could not be established. The X-ray studies rather suggest that the alteration took place directly to kaolinite, since no sericite could be detected in the partially kaolinised felspars. The sericite that is present may have been formed under the present arid climatic conditions, where there is rather slow leaching of potash due to the low rainfall.

C. CONCLUSIONS

The absence of any evidence of hydrothermal activity in this area after the Nama period precludes the postulation of a hydrothermal theory of origin for these deposits. There are no metalliferous sulphide deposits or thermal springs that could have been instrumental in the genesis of the deposits. The absence of any coal beds which may indicate the former existence of swamps or bogs suggests that the kaolin could not have been formed by downward percolating waters rich in organic material from such sources.

The only conclusion one can reach, therefore, is that these deposits were formed by the surface weathering of felspathic rocks poor in ferromagnesian minerals, and, as has been pointed out, this deduction, based here on purely negative evidence, receives positive support from the superficial nature of the kaolin bodies and the fact that kaolinisation is related to surfaces of erosion. Faults acted as natural channels for the downward movement of surface waters, from there the tendency for the larger deposits to be located on or near faults. The reason why these deposits are so different from the ordinary weathering products of similar rocks may be that chemical weathering predominated over mechanical weathering which in particular facilitates the introduction of foreign material from outside.

The climatic conditions at the time of formation of these deposits were probably much more humid than today.

Conditions were probably such as to cause the rapid leaching of potash with the result that the felspar changed directly into kaolinite instead of through an intermediate stage of secondary mica. Some silica was undoubtedly leached from the rocks at this stage and redeposited in part as secondary quartz, and possibly in part as surface quartzite (e.g. Hendriksvlei).

APPENDIX

KAOLIN (CHINA CLAY)

A. DEFINITION

China clay or kaolin is a white or near white clay. Although widespread in nature, it is found in relatively few localities in commercially workable quantities. The terms "China clay" and "kaolin" are synonymous, but the latter has been more frequently employed in scientific work and will be used in this bulletin. Kaolin is a product of weathering, and will therefore contain, to a varying degree, other non-clay products such as mica, quartz and felspar.

According to the geological character of the deposit, kaolin will fall into one of two groups :-

(i) Residual or primary kaolin found at the original point of formation.

(ii) Sedimentary, transported or secondary kaolin which has been carried from the point of formation and deposited elsewhere.

As the latter type has been subjected to a degree of natural beneficiation, these deposits generally contain more clay material. Secondary kaolins containing from 80 to 99 per cent. clay are known. The residual kaolins are invariably heavily contaminated with gangue material and many deposits being exploited yield only 15 - 25 per cent. kaolin.

Lesser amounts of other clay minerals may be present, and with their different base exchange capacities will profoundly influence the working properties of the refined clay.

The essential constituent of kaolin is the mineral kaolinite, a hydrated aluminium silicate that may be represented by the empirical formula Al_2O_3-$2SiO_2$-$2H_2O$. The accessory constituents of a kaolin are more or less finely divided quartz, felspar, mica, etc.

The kaolin group comprises the following clay minerals: kaolinite, nacrite, dickite and halloysite with kaolinite as the chief member. Kaolinite is characterised by having a stable, non-expanding type of crystal lattice; flat plate-like hexagonal particles normally less than about 5μ in diameter; a low base-exchange capacity; and usually a white or nearly white colour.

The purified material contains only minor amounts of iron and magnesium, which explains the refractory nature of kaolinite and consequently its use as a raw material in the ceramic industry.

B. USES AND SPECIFICATIONS

It is of interest to note the distribution of kaolin consumed in various industries in the U.S.A.

Paper industry 60%

Ceramic industry 15%

Other industries 25%

Kaolin has found a great number of uses in various fields of industry: the following are the more important.

1. Ceramics

The unusual clay-water properties of kaolins, namely plasticity and slip-forming characteristics, are important in the forming processes (jiggering and casting) of dinner-ware and sanitary ware. The extremely small particles and flat plate-like shapes of kaolinite also impart strength to green ware which is important in the production of wall tile and electrical insulators. Finally, the white fired colour of kaolins is important in the above-mentioned products and the field of white-wares generally.

A beneficiated kaolin with a desirable green strength and workability properties usually has a particle size distribution with a relatively high percentage of particles of the order of 0.25μ and less in diameter. The dry modulus of rupture is generally in the range of 200 - 250 p.s.i. To obtain a good fired colour, the Fe_2O_3 content should be of the order of 0.5 per cent.

Typical particle size and chemical analysis of,

for example, some American kaolins vary as follows:

Particle Size

	%
Under 2μ	40 - 92
Above 5μ	3 - 35

Chemical Analysis

Al_2O_3	37.41 - 39.18
SiO_2	44.56 - 45.01
Fe_2O_3	0.34 - 1.63
TiO_2	1.30 - 1.62
CaO	0.004- 0.13
MgO	0.003- 0.03
K_2O	0.002- 0.11
Na_2O	0.004- 0.1
Loss Ign.	13.89 - 14.17

2. Paper

A sheet of cellulose fibre, such as newsprint, is not suited to high fidelity printing, due to the transparent structure and irregularity of surface. These deficiencies can be corrected by the incorporation of a fine mineral filler coupled with a binding agent such as starch or resin into the fibre stock. The tiny particles of the filler are trapped in the voids between the fibres providing a finer-textured surface of improved brightness, opacity and smoothness. Kaolin is one of the most commonly used fillers.

Although such a paper is satisfactory for normal

printing, it still lacks the perfection of surface required for high-class magazine work. For such purposes, the quality of the filled sheet can be enhanced by coating the surface with a thin film of a finely divided mineral pigment suspended in an adhesive mixture, such as casein. Again the inherent properties and low cost of kaolin cause it to be the most widely used pigment.

The clay content in uncoated papers can vary widely, but 10 per cent. by weight might be taken as an average figure. The value in coated papers is somewhat higher and in the case of magazine paper the clay present is about 25 per cent. of the weight of paper.

The most critical specifications in the selection of a filler clay are as follows.

(a) Brightness

The effect of the brightness of the clay on the appearance of the finished sheet is self-evident. Traces of heavy minerals such as haematite or ilmenite that impart colour, or the presence of organic matter, would reduce the reflectance of the clay as measured with a G.E. reflection meter. A G.E. brightness of 80 per cent. would be considered satisfactory.

(b) Abrasiveness

It is important that abrasive foreign material such as fine quartz should be kept to a minimum to prevent undue wear on the Foudrinnier machine. Greater variation in abrasiveness usually occurs in filler grades of kaolin, where the same degree of fineness is not required and the

refining techniques are not as selective. An easy measure of relative abrasiveness is possible with the Valley iron tester. Absolute values are, however, difficult to obtain.

(c) Grit content

This is coupled with abrasiveness, although the two are not necessarily synonymous. The residue of a 325 mesh screen is taken as a measure of the grit content. Although the amount of screen residue is not a reflection on the quality of the fine material passing through, it is important as it is likely to mar the final surface, apart from increasing the abrasion.

(d) Fineness

The particle size distribution has an important bearing on the capacity and colour of the paper, and the retention of the filler in the fibres. Both the opacity and reflectance increase with decrease in particle size.

Typical average specifications for filler and coating paper-grade clays overseas are :

	μ	Filler Grades %	Coating Grades μ	Coating Grades %
Screen Residue 200 mesh (% max.)		0.03 - 0.05		0.005-0.007
Particle Size Distribution	μ	%	μ	%
			+10	0 - 1
	+5	15.8 -30.5	5-10	3.9- 6.6
	4 - 5	4.2 - 5.5		2.7- 4.2
	3 - 4	5.7 - 6.3		4.4- 6.8
	2 - 3	8.9 - 7.8		9.0- 9.4
	1 - 2	18.4 -11.9		25.5-23.9
	0.5 - 1	16.2 -16.0		25.4-24.1
	-0.5	30.8 -22.0		29.1-24.0
	Above 5	15.8 -30.5		3.9- 7.6
	Finer than 2	65.4 -49.9		80.0-72.0
Reflectivity (G.E. Brightness)		79 -83.5		83.5-85.5

3. Rubber

Clay is used in rubber because of its reinforcing and stiffening properties, and because of its low cost in comparison with other rubber pigments. Kaolins vary in their reinforcing properties, and a rough subdivision of rubber clays into 'hard' and 'soft' is made on this basis. Kaolins producing rubber of high modulus, tensile strength, resistance to abrasion, and producing stiff, uncured compounds are called 'hard'. This is an arbitrary classification and has no connection with geological formation or chemical composition. Variation in colour, viscosity, oil absorption and settling characteristics between hard and soft

clays have been noted, but there has been no quantitative relationship developed between these factors and the 'hardness' of the compounded rubber. It has been stated that the difference in behaviour might be due to the particle shape of the kaolin grains. Soft clays have been fractionated in the laboratory to duplicate the particle size distribution of a known hard clay, yet the two clays exhibited widely different characteristics in rubber. This difference could be accounted for on a basis of variation in shape. Hard clays are rare and it is understood that the entire world supply is produced from one deposit in South Carolina.

Hard clays give excellent resistance to abrasion and are used extensively where this factor is important. In articles where abrasion is not a factor, and cheapness is required, soft kaolin is used.

A high grit content for rubber clays is objectionable, as it induces premature flex cracking and increases the wear on the mixing machines. Suppliers of one type of soft clay of rubber grade, report grit on 325 mesh as not exceeding 0.3 per cent. The presence of mica is considered objectionable in the manufacture of extracted rubber goods. Chemical analysis is not considered of much importance in evaluating the suitability of rubber clays, although the presence of manganese and iron is considered to exert a harmful effect on the ageing properties of the cured rubber. Apparently the form in which these impurities are present exerts influence on the ageing of the rubber. However, physical tests on the compounded rubber still form the

final basis for acceptance.

South African rubber manufacturers consider the domestic kaolins as "soft". Basically, their requirements are for a white clay, substantially free from grit, with a moisture content below 1 per cent., and of consistent quality.

Typical analysis of rubber clays is :-

		%
Screen Residue	+325 mesh	0.02 - 0.17
Moisture		± 1
Particle Size	-2μ	55 - 92
	$+5\mu$	3 - 25

4. Pain

The new easy-to-apply, matte-surface paints contain a high percentage of kaolin. Kaolin as an inert and insoluble additive is ideal as an extender because of its high covering power, smooth flow properties and low cost.

5. Plastics

In the field of plastics, the addition of kaolin to thermosetting and thermoplastic mixes results in products with a smooth surface, attractive finish, good dimensional stability and high resistance to chemical attack. The flat kaolin platelets obscure the reinforcing fibres and flow easily to simplify the moulding of complex shapes.

6. Insecticides

Kaolin acts as an effective carrying agent for insecticides now in wide-scale use. The inertness, low abrasiveness, and good adsorption and flow properties of kaolin

make it suitable for both dust and spray forms of insecticides.

OPSOMMING IN AFRIKAANS

DIE KAOLIENAFSETTINGS VAN DIE GEBIED TUSSEN BITTERFONTEIN EN LANDPLAAS, DISTRIK VANRHYNSDORP

INLEIDING

Die gebied is geleë in die Distrik Vanrhynsdorp in die omgewing van Nuwerus, Bitterfontein en Landplaas. Bitterfontein is die eindpunt van die spoor vanaf Kaapstad, en die hoofpad vanaf Vanrhynsdorp na Springbok loop deur Nuwerus en Bitterfontein. Provinsiale en plaaspaaie verbind al die dorpies en plase met mekaar.

Die gebied bestaan hoofsaaklik uit ŉ heuwelagtige landstreek in die ooste wat deur ŉ sanderige kusvlakte in die weste begrens word. Sommige van die hoër berge in die ooste wat deur Namakwartsiet oordek word, bereik ŉ hoogte van 1,150 tot 1,900 voet bo seespieël.

Die gebied is woestynagtig en die gemiddelde reënval is minder as 250 mm. per jaar. Alle riviere is nie-standhoudend en water word hoofsaaklik uit boorgate verkry. Die gehalte van die boorgatwater is oor die algemeen swak deurdat dit ŉ groot persentasie opgeloste vaste stowwe bevat.

ALGEMENE GEOLOGIE

Kwartsiet, filliet en kalksteen van die Formasie

Malmesbury kom voor in die suidoostelike gedeelte van die gebied en is die oudste gesteentes wat hier aangetref word. (Kyk voublad 1.)

ŉ Eerste siklus van metamorfose, metasomatose en granitisasie van Malmesburysediment het die ontstaan van die ligrooskleurige gneis en granuliet, wat die grootste gedeelte van die gebied beslaan, tot gevolg gehad.

Porfiroblastiese graniet, granodioriet, dioriet en gneis het ontstaan gedurende die tweede siklus van metamorfose, metasomatose en granitisasie. Hierdie gesteentes kom hoofsaaklik in die noordelike gedeelte van die gebied voor.

Kwartsiet en skalie van die Sisteem Nama oorlê die vroeëre of gneisige gesteentes en kom hoofsaaklik voor in die oostelike en noordoostelike gedeelte van die gebied.

Tersiêre afsettings word verteenwoordig deur oppervlakkwartsiet, sandsteen, gruis, merrel, en klei met ligniet. Waaisand, spoelgrond, rivierterrasgruis en strandterrasafsettings behoort tot die Kwaternêr. Na-Namaverskuiwings kom uitgebreid voor.

DIE KAOLIENAFSETTINGS

Die lokaliteite van die afsettings word op voublad 1 aangedui.

OOSTELIKE AFSETTINGS

Afsetting 1 (Nieuwhoudts Naauwte)

Die afsetting, wat al voorheen gedelf is, kom voor tussen twee na-Namaverskuiwings op die skuinste van ŉ heuwel.

ɳ Kaart van die afsetting verskyn op voublad 2.

Verskeie prospekteergate is gegrawe. Die kaolien, wat die ontbindingsproduk van granietgneis is, wissel heelwat in gehalte. In plekke is dit rooi, ligroos of geel gekleur.

Na beraming sal die afsetting ongeveer 312,000 ton skoon, gewaste, wit kaolien kan oplewer. Hierdie syfer is gebaseer op ɳ winning van 40 persent uit die gesorteerde, wit roumateriaal. Die gewaste materiaal kan verbruik word in die papier-, keramiese, verf-, rubber-, en insekdoders-industrieë, want dit is fyn, brand wit, en het ɳ reflektiwiteitswaarde van tot 86.

Afsetting 2 (Erd Vark Gat)

Hierdie afsetting was vroeër deur die Brackenware Company gedelf.

Dit kom voor op ɳ verskuiwing aan die voet van ɳ heuwel. Die ou delfplek het ɳ werkfront 200 voet lank en 25 voet hoog.

Die kaolien is oor die algemeen van goeie, wit gehalte en bevat growwe kwartsstukkies. Die moedergesteente was granietgneis.

Prospekteergate het getoon dat kaolien oor ɳ betreklik groot afstand teen die glooiing van die heuwel op voorkom en reserwes is dus ongetwyfeld groot. Die gewaste materiaal is redelik fyn (66 persent -10μ), en het ɳ reflektiwiteitswaarde van 77.

Afsetting 3 (De Toekomst)

Dit is aan die voet van ɳ heuwel en langs dieselfde

verskuiwing as afsetting nr. 2 geleë. 'n Kaart van die afsetting word op voublad 3 aangegee.

Prospektering het bewys dat die afsetting 'n oppervlakte van ongeveer 200 jaarts by 200 jaarts beslaan. Die kaolien is die ontbindingsproduk van granietgneis en granuliet en kom voor onder 'n deklaag van grond en sand van 1 tot 5 voet in dikte. Die kaolien is oor die algemeen wit, maar in sommige gate het geel materiaal dieper na onder voorgekom. In sekere gate is opgemerk dat die kaolien afwaarts gradeer in ongekaoliniseerde materiaal.

Na beraming is daar 'n reserwe van 250,000 ton wit kaolien. Die kaolien het dieselfde verbruiksmoontlikhede as dié van Nieuwhoudts Naauwte; die gewaste materiaal is ietwat fyner as die vorige (81 persent -5μ) en het 'n reflektiwiteitswaarde wat wissel van 62.5 tot 82.5 .

Afsetting 8 (De Toekomst)

Dit kom in 'n sone van kwartsare, op 'n verskuiwing, voor. Prospektering is ook by hierdie afsetting gedoen. Kyk fig. 2.

Die kaolien is die produk van die verandering van 'n grofkorrelrige granietgneis en 'n sanderige kwarts-veldspaatgranuliet. Die kaolien gaan op plekke oor in ongekaoliniseerde gesteente.

Prospektering het bewys dat daar ongeveer 250,000 ton wit kaolien beskikbaar is.

Gewaste materiaal van hierdie afsetting kan in dieselfde indústrieë verbruik word as dié van Nieuwhoudts Naauwte; 88 persent van die gewaste materiaal het 'n

partikelgrootte kleiner as 5μ , en die reflektiwiteitswaarde van die afsetting as geheel wissel tussen 69 en 85.

Afsettings 18 en 19 (Kersbosvlei)

Die kaolien is oor 'n afstand van ongeveer 1.5 myl in die pad en in prospekteergate langs die pad blootgelê. Dit blyk enkele geïsoleerde kolle van kaolien te wees.

Die kaolien, wat van gneis en granuliet afkomstig is, is oor die algemeen van swak gehalte daar dit op meeste plekke gekleur is en ook baie kwarts bevat. Geen noemenswaardige reserwes is tot dusver bewys nie.

Klein Voorkomste in die Ooste

Voorkomste by 9, 10, 11, 12, 14, 15, 16 en 17, blyk almal van klein omvang te wees en die gehalte is ook gewoonlik minderwaardig. Prospekteergate is slegs by voorkomste 15, 16 en 17 gemaak.

WESTELIKE AFSETTINGS

Afsettings 4 en 5 (Moedgewin)

Afsetting 4 kom voor op 'n verskuiwingsone, gekenmerk deur 'n sone van dun kwartsare. Kyk voublad 4. Die kaolien, wat die ontbindingsproduk van granietgneis, granuliet en skis is, dra 'n deklaag wat wissel van 'n paar duim tot 3 voet.

Die beste gehalte, wit, kwartslose kaolien kom in die sone van kwartsare voor. Hierdie gedeelte is waarskynlik van pegmatiet afkomstig. Die kaolien is gekleur in plekke.

Prospektering het bewys dat daar 'n reserwe van ongeveer

46,500 ton wit, gewaste kaolien sal wees; tot 77 persent van die gewaste materiaal het 'n partikelgrootte kleiner as 5µ , en die reflektiwiteitswaarde is tot 86.

Afsetting 5 blyk heelwat kleiner te wees. Wit sowel as gekleurde materiaal van goeie gehalte is in die prospekteergate opgemerk. Die kaolien vertoon eienskappe wat as belangrik beskou word in die papier- en insekdodersindustrieë.

Afsetting 20 (Klipkraal)

Die kaolien is in die wal van 'n rivier oor 'n afstand van ongeveer 200 voet blootgelê en het 'n sigbare dikte van ongeveer 12 voet. Die kaolien is gewoonlik sag en gekleur. Dit is nie bekend hoe 'n groot oppervlakte deur kaolien beslaan word nie, aangesien dit deur 'n dik laag van grond en sand, verskeie voet dik, bedek word. Geen prospekteerwerk is hier gedoen nie.

Afsetting 21 (Hendriksvlei)

Die kaolien is die primêre ontbindingsproduk van granietgneis en skis en dit kom oor 'n groot gebied voor. Kyk voublad 5. Die kaolien word oordek met 'n laag sand en grond wat wissel van 'n paar duim tot 20 voet in plekke.

Die kaolien is byna uitsluitlik wit, maar dit bevat heelwat kwarts en mika in plekke. Sommige van die prospekteergate het getoon dat daar 'n geleidelike oorgang van kaolien tot relatief vars moedergesteente is.

Na beraming is daar ongeveer 1,500,000 ton roumateriaal van goeie gehalte, 7,700,000 ton roumateriaal van

middelmatige gehalte en 9,000,000 ton roumateriaal van swak gehalte, dus ꞌn totaal van 12,200,000 ton. Hierdie afsetting moet as baie belowend beskou word; die herwinning op -325-maas is tot 62 persent, en die reflektiwiteitswaarde tot 85.

Afsettings 6 en 7

Hierdie twee afsettings blyk op dieselfde verskuiwing as afsetting 4 te lê. Die afsettings is van klein omvang en die gehalte wissel heelwat. Daar is ꞌn paar prospekteergate gemaak waar geen noemenswaardige reserwes blyk teenwoordig te wees nie.

Afsetting 22

Kaolien is slegs in ꞌn enkele prospekteergat blootgelê. Dit kan aanbeveel word dat verdere prospekteerwerk hier gedoen word aangesien die kaolien nie van slegte gehalte is nie en dit is ook naby die spoor geleë.

Afsetting 24

Die kaolien is teen die hang van ꞌn lae heuwel in spoelslote blootgelê. Daar is te min kaolien van goeie gehalte om van die afsetting ꞌn ekonomiese proposisie te maak.

Afsetting 25

Wit kaolien van betreklike goeie gehalte is blootgelê in ꞌn klein gronddammetjie. Prospektering word aanbeveel.

Afsetting 23

Kaolien van betreklike goeie gehalte kom voor in putte in die rivierbedding. Dit is bedek met 'n laag sand en grond van 5 tot 10 voet dik.

Afsetting 26

Gekaoliniseerde gneis, bedek deur oppervlakafsettings, kom voor in die vorm van lae, plat randjies. Die gehalte is oor die algemeen baie swak.

KAOLIEN (PORSELEINAARDE)

Definisie

Die essensiële bestanddeel van kaolien is die mineraal kaoliniet, 'n gehidreerde aluminiumsilikaat, wat gevorm word deur die ontbinding van veldspaat of ander aluminiumsilikate.

Residuele (primêre) kaolienafsettings word aangetref op die plek van hul ontstaan, maar sedimentêre (sekondêre) kaolienafsettings is deur wind of water vanaf hul oorspronklike plekke van ontstaan na ander plekke vervoer.

Gebruike en Spesifikasies

Die vernaamste gebruike van kaolien is in die keramiek- en papierindustrieë. Dit word ook gebruik in die vervaardiging van rubber, verf, plastiek, en insekdoders. In die rubber- en papierindustrieë word dit hoofsaaklik vereis dat die kaolien baie fyn moet wees en 'n lae gruisinhoud moet hê. Kleur speel 'n belangrike rol in die

keramiese industrie, wat vereis dat die kaolien so wit as moontlik moet wees.

Partikelgrootte en vorm speel 'n belangrike rol as die klei gebruik word in verf, plastiek en insekdoders.

ONTSTAAN VAN DIE KAOLIEN

Die kaolienafsettings in hierdie gebied is almal die primêre residuele ontbindingsprodukte van veldspaatryke gesteentes soos gneis, graniet en granuliet.

Daar bestaan verskillende teorieë oor die agente wat kaolinisering van veldspaat teweegbring, die vernaamste waarvan is:

1. Oppervlakverwering.
2. Water wat afsak vanaf moerasse.
3. Emanasies wat volg op eruptiewe werking.
4. Opwaartsbewegende waters van warmbronne wat koolsuurgas bevat.
5. Swawelsuuroplossings en swawelwaterstof.

Alle beskikbare gegewens dui daarop dat die kaolienafsettings in die gebied ontstaan het as gevolg van oppervlakverwering van veldspatiese gesteentes. Die spierwit klei is afkomstig van gesteentes wat in die eerste plek min ysterdraende minerale bevat het. Meganiese verwering kon nie 'n groot rol gespeel het nie aangesien dit sou meebring dat onsuiwerhede in die vorm van ysteroksiede byvoorbeeld, in die afsettings sou indring.

Laboratoriumondersoek van die gekaoliniseerde materiaal het aan die lig gebring dat die veldspaat waarskynlik direk oorgegaan het in kaoliniet en nie deur 'n tussensta-

duim van serisiet nie.

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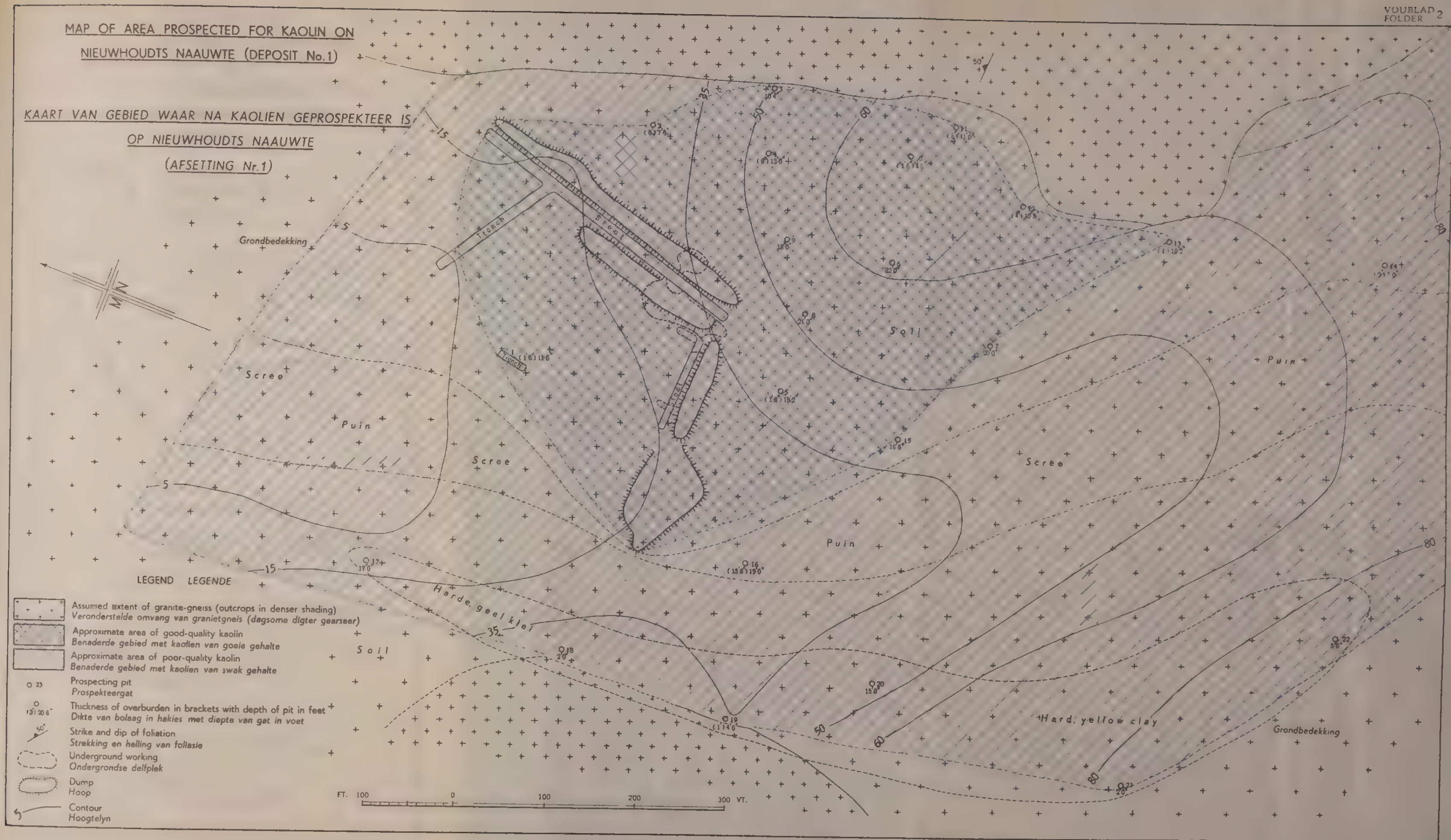
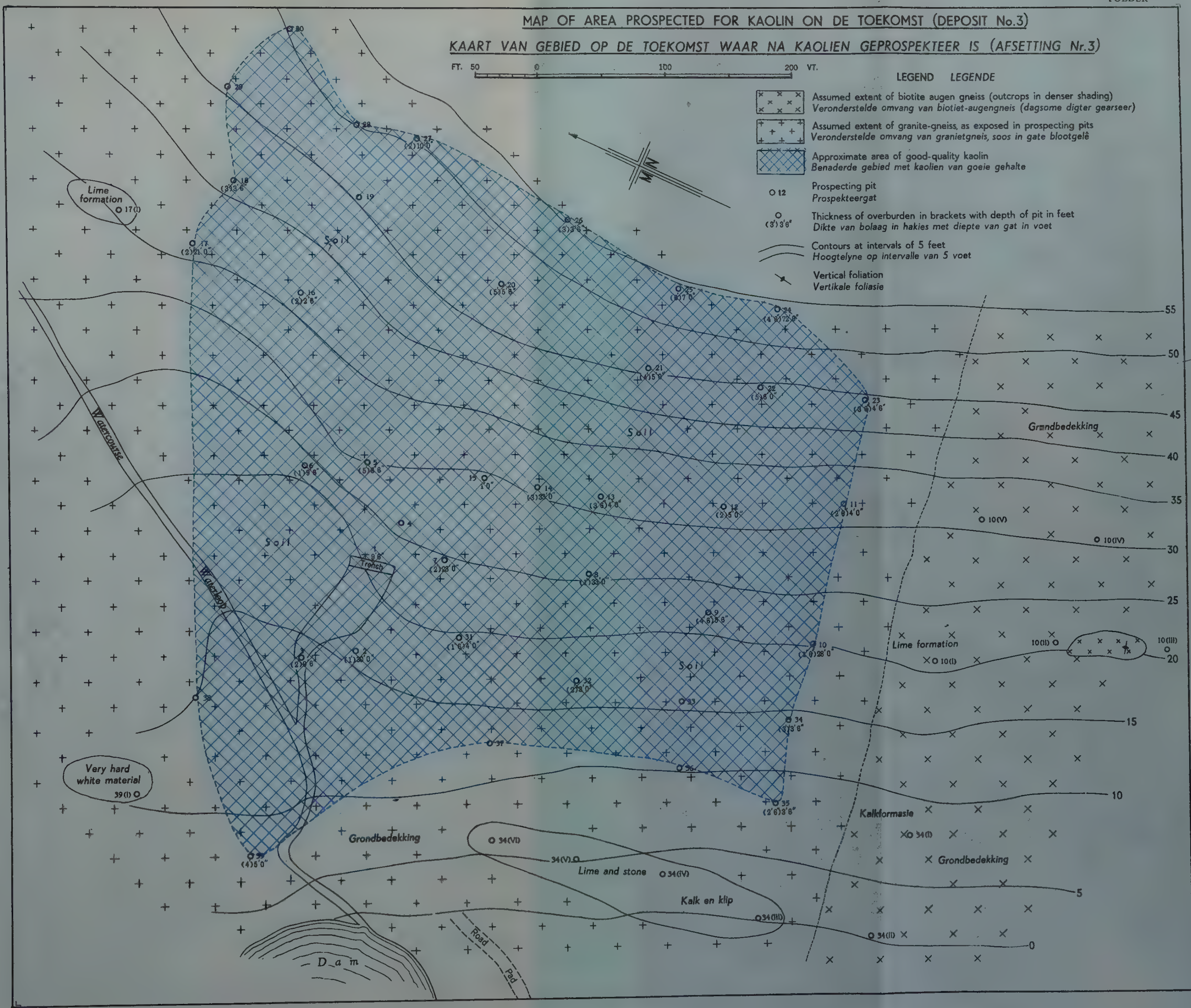
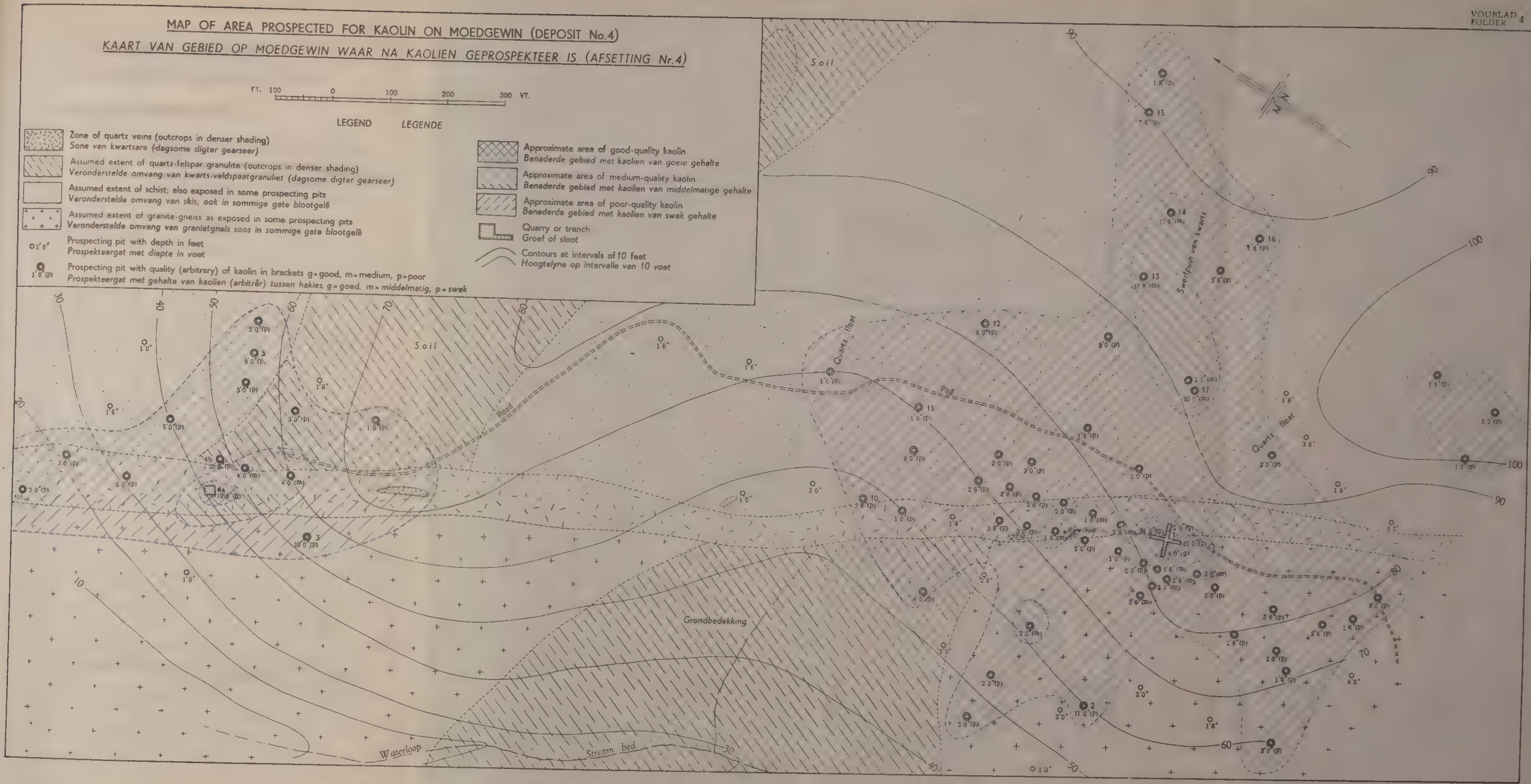
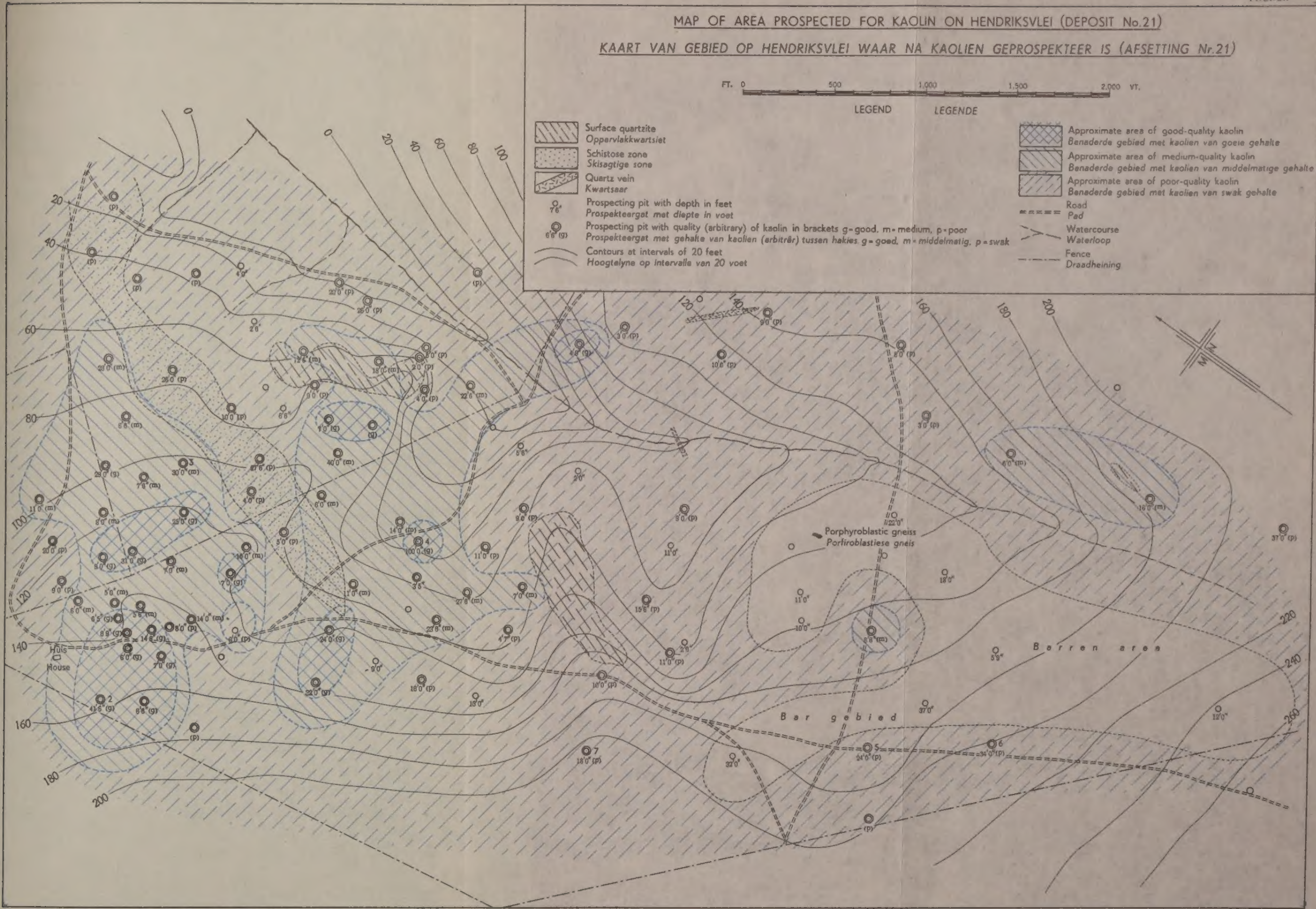
PLATE I.—Kaolin quarry on Erd Vark Gat south of Nuwerus (occurrence No. 2).


MAP OF AREA PROSPECTED FOR KAOLIN ON
NIEUWHOUDTS NAAUWTE (DEPOSIT No.1)
KAART VAN GEBIED WAAR NA KAOLIEN GEPROSPEKTEER IS
OP NIEUWHOUDTS NAAUWTE
(AFSETTING Nr.1)
Grondbedekking
Scree
Puin
Scree
Soil
Puin
Scree
Puin
Harde geel klei
Soil
Hard yellow clay
Grondbedekking
Trench
Stoot
LEGEND LEGENDE
Assumed extent of granite-gneiss (outcrops in denser shading)
Veronderstelde omvang van granietgneis (dagsome digter gearseer)
Approximate area of good-quality kaolin
Benaderde gebied met kaolien van goeie gehalte
Approximate area of poor-quality kaolin
Benaderde gebied met kaolien van swak gehalte
Prospecting pit
Prospekteergat
Thickness of overburden in brackets with depth of pit in feet
Dikte van bolaag in hakies met diepte van gat in voet
Strike and dip of foliation
Strekking en helling van foliasie
Underground working
Ondergrondse delfplek
Dump
Hoop
Contour
Hoogtelyn
FT. 100 0 100 200 300 VT.


MAP OF AREA PROSPECTED FOR KAOLIN ON DE TOEKOMST (DEPOSIT No.3)
KAART VAN GEBIED OP DE TOEKOMST WAAR NA KAOLIEN GEPROSPEKTEER IS (AFSETTING Nr.3)
FT. 50 0 100 200 VT.
LEGEND LEGENDE
Assumed extent of biotite augen gneiss (outcrops in denser shading)
Veronderstelde omvang van biotiet-augengneis (dagsome digter gearseer)
Assumed extent of granite-gneiss, as exposed in prospecting pits
Veronderstelde omvang van granietgneis, soos in gate blootgelê
Approximate area of good-quality kaolin
Benaderde gebied met kaolien van goeie gehalte
Prospecting pit
Prospekteergat
Thickness of overburden in brackets with depth of pit in feet
Dikte van bolaag in hakies met diepte van gat in voet
Contours at intervals of 5 feet
Hoogtelyne op intervalle van 5 voet
Vertical foliation
Vertikale foliasie
M N
Lime formation
Soil
Watercourse
Waterloop
Trench
Lime formation
Kalkformasie
Grondbedekking
Very hard white material
Lime and stone
Kalk en klip
Road
Pad
Dam
55
50
45
40
35
30
25
20
15
10
5
0


MAP OF AREA PROSPECTED FOR KAOLIN ON MOEDGEWIN (DEPOSIT No.4)
KAART VAN GEBIED OP MOEDGEWIN WAAR NA KAOLIEN GEPROSPEKTEER IS (AFSETTING Nr.4)
FT. 100 0 100 200 300 VT.
LEGEND LEGENDE
Zone of quartz veins (outcrops in denser shading)
Sone van kwartsare (dagsome digter gearseer)
Assumed extent of quartz-felspar granulite (outcrops in denser shading)
Veronderstelde omvang van kwarts-veldspaatgranuliet (dagsome digter gearseer)
Assumed extent of schist; also exposed in some prospecting pits
Veronderstelde omvang van skis; ook in sommige gate blootgelê
Assumed extent of granite-gneiss as exposed in some prospecting pits
Veronderstelde omvang van granietgneis soos in sommige gate blootgelê
Prospecting pit with depth in feet
Prospekteergat met diepte in voet
Prospecting pit with quality (arbitrary) of kaolin in brackets g=good, m=medium, p=poor
Prospekteergat met gehalte van kaolien (arbitrêr) tussen hakies, g=goed, m=middelmatig, p=swak
Approximate area of good-quality kaolin
Benaderde gebied met kaolien van goeie gehalte
Approximate area of medium-quality kaolin
Benaderde gebied met kaolien van middelmatige gehalte
Approximate area of poor-quality kaolin
Benaderde gebied met kaolien van swak gehalte
Quarry or trench
Groef of sloot
Contours at intervals of 10 feet
Hoogtelyne op intervalle van 10 voet
Soil
Road
Pad
Quartz float
Swerfpuin van kwarts
Grondbedekking
Waterloop
Stream bed
Bore-hole
N


MAP OF AREA PROSPECTED FOR KAOLIN ON HENDRIKSVLEI (DEPOSIT No.21)
KAART VAN GEBIED OP HENDRIKSVLEI WAAR NA KAOLIEN GEPROSPEKTEER IS (AFSETTING Nr.21)
FT. 0 500 1,000 1,500 2,000 VT.
LEGEND LEGENDE
Surface quartzite
Oppervlakkwartsiet
Schistose zone
Skisagtige sone
Quartz vein
Kwartsaar
Prospecting pit with depth in feet
Prospekteergat met diepte in voet
Prospecting pit with quality (arbitrary) of kaolin in brackets g = good, m = medium, p = poor
Prospekteergat met gehalte van kaolien (arbitrêr) tussen hakies. g = goed, m = middelmatig, p = swak
Contours at intervals of 20 feet
Hoogtelyne op intervalle van 20 voet
Approximate area of good-quality kaolin
Benaderde gebied met kaolien van goeie gehalte
Approximate area of medium-quality kaolin
Benaderde gebied met kaolien van middelmatige gehalte
Approximate area of poor-quality kaolin
Benaderde gebied met kaolien van swak gehalte
Road
Pad
Watercourse
Waterloop
Fence
Draadheining
Porphyroblastic gneiss
Porfiroblastiese gneis
Barren area
Bar gebied
Huis
House
N